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SCIENTIFIC-ATLANTA, INC.
P. O. Box 13654, Atlanta, Ga. 30324

INSTRUCTION MANUAL

AUTOTRACK ANTENNA
SYSTEM
K482

ME-7116

Image Information, Incorporated
22 Elizabeth Street
Norwalk, Connecticut 06856

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SECTION 1
GENERAL INFORMATION

1.1 GENERAL

This instruction manual defines the operation of the Image Information Incorporated Autotrack Antenna System manufactured by Scientific-Atlanta, Incorporated.

1.2 APPLICABLE DOCUMENTS

The following Scientific-Atlanta instruction manuals form a part of this publication.

- Series 3200 Tracking Pedestal
- Model 73 Tracking Feed Assembly
- Series 3616 Servo Control Unit
- Model 3623B Servo Amplifier and Models 3635A and 3636A Power Amplifiers
- Series 3730 Manual Command Units
- Series 3710 Position Indicator Units
- Model 3753-4 Sector Scan Unit
- Models 3774-4, -5, and -6 Tracking Converter Unit
- Model 3775A Scan Code Generator
- Model 410A/( ) 10-MHz Bandwidth Telemetry Receiver
- Model 429 DF VHF Tuner
- Model 440 FM Demodulator
- Series 430 IF Filter
- Models 457-7 and 457-8 Subcarrier Demodulators
- Model 450B Spectrum Display Unit
- Model 3595 Up-Converter

1.3 GENERAL DESCRIPTION

This section describes the general operation of the system and the interrelation of the various units which make up the system. The detailed descriptions of the individual units are contained in the unit manuals listed in paragraph 1.2. Figure 1-1 is the functional block diagram of the system.

1.3.1 ACTUATING ERROR SIGNAL AND PEDESTAL DRIVE MECHANISM

In all modes of operation except standby, the rate amplifier in the servo control unit receives an actuation error signal. The amplifier gain-versus-frequency characteristics are determined by servo compensation circuits associated with the amplifier. These networks are switched for each mode. The magnitude and polarity of the output of the amplifier represent the required amount and direction of pedestal rotation. This output is fed from the servo control unit through the current limiter to the servo control amplifier (SCA) in the servo amplifier chassis. The SCA uses this dc error voltage to generate a train of control pulses on either its forward or reverse output channel. The pulse train is synchronized with the powerline frequency; the number and phase of pulses per half-cycle is proportional to the magnitude of the actuating error signal. In the power amplifier at the pedestal, receipt of the control pulses on either the forward or reverse input will supply the dc drive motor with power for the required rotation. The magnitude of the dc drive current and power delivered to the pedestal load depends on the number of control pulses in each train, which establishes the firing angle of the silicon controlled rectifiers (SCR's) on each half cycle of the powerline voltage.

To ensure that the average power rating of the drive motor is not exceeded under heavy loads, a current-sensing device in the power amplifier supplies a voltage to operate a current limiter in the servo amplifier. The current limiter averages this voltage and clamps the actuating error signal input of the SCA to the appropriate maximum value.

A tachometer, attached to the shaft of the motor on each axis, generates a dc voltage proportaional to the pedestal rotation speed. In the servo control unit, the tachometer feedback signal is combined with the error signal at the rate amplifier. The insertion of a feedback voltage proportional to the rotation speed $\frac{d\theta}{dt}$ allows the control system to reduce or increase the actuating error so as to counteract antenna momentum and stabilize against varying external loads.

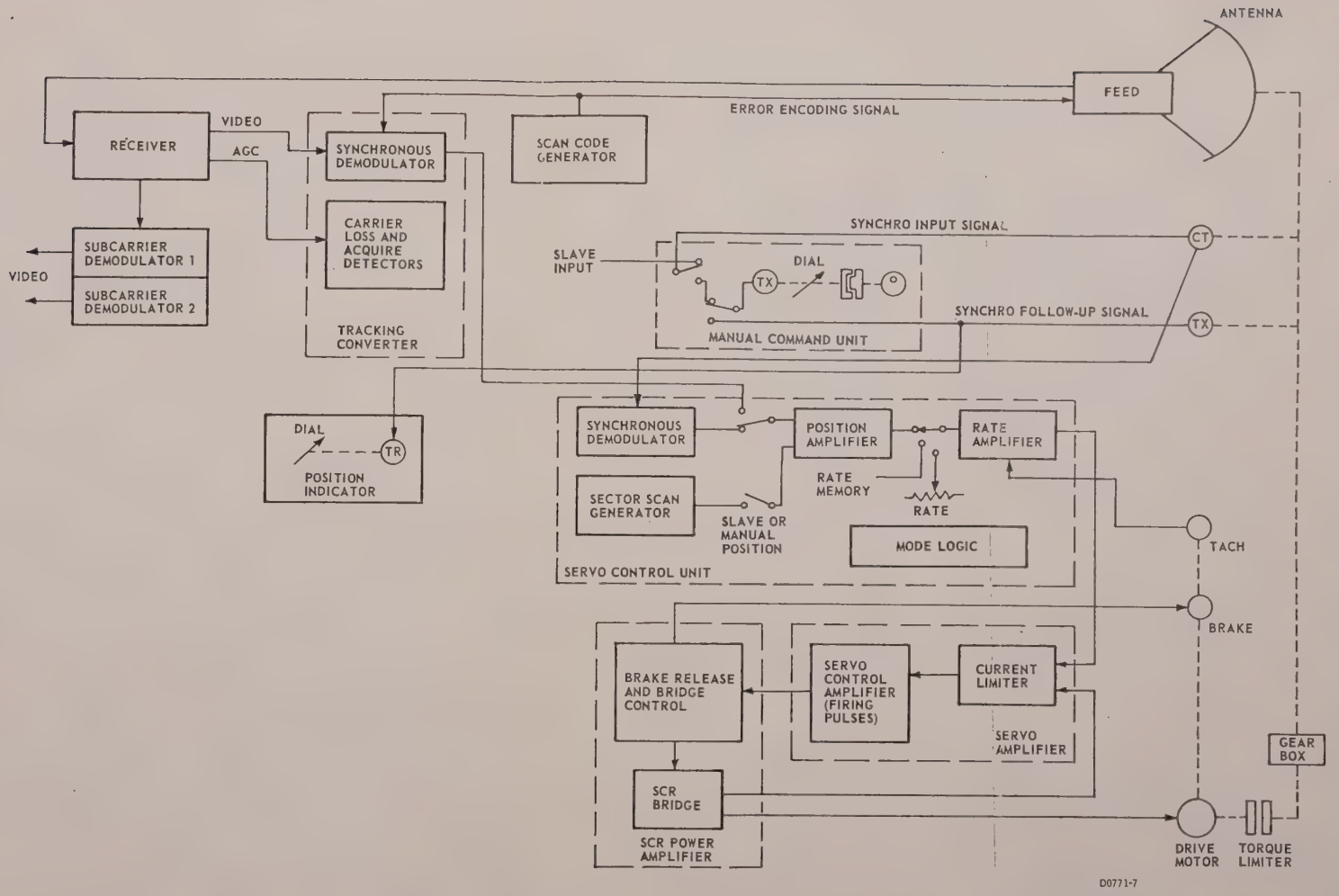


Figure 1-1. Functional Block Diagram
One Axis

The motor on each pedestal axis drives the respective turntables through power gear trains. The azimuth axis has a motor, a gearbox, one ring gear, and one turntable. The elevation axis has a motor, a gearbox, two ring gears, and two turntables which are connected by a torque tube.

A electromechanical brake is attached to the shaft of each motor. For fail-safe operation, the brakes are applied by spring-loading and released when electrically energized. The brakes are automatically applied when the power is off, the stand-by mode is selected, a limit switch is actuated, or the stow pin is not in its storage receptacle. The brakes on each axis are released when the manual brake release is disengaged and the handcrank is engaged; this also actuates an interlock to prevent application of drive power. If a stow-lock pin is removed from its storage receptacle, interlock switches de-energize the equipment.

If a pedestal axis is rotated to the end of its sector, a limit switch prevents further rotation in that direction and lights the proper LIMIT indicator. Automatic back-out circuits release the brakes and energize the equipment when the controls are operated to drive the pedestal in a direction opposite to the actuated limit switch.

Data takeoff units are connected to the output ring gear on each axis by means of antibacklash gears. The data takeoff units contain synchros and other optional data devices as required for the system supplied (see figure 1-1).

The stator of the synchro control transformer (CT) in the data takeoff units are energized by either the remote slave synchro input signal or the manual command unit, and rotor outputs are fed to the demodulators in the servo control unit as an ac error signal.

The outputs from the synchro transmitters (TX's) in the pedestal are connected to the local position indicator.

The pedestal TX is connected to the manual command servo follow-up as well as to the pedestal slave output.

1.3.2 SLAVE MODE

The mode select logic switching configuration for the slave mode with the slave input signal fed from a remote source is shown in figure 1-1.

The stators of the 1:1 control transformers (CT's) in the pedestal are eventually connected to the TX's in the remote equipment. Any time the pointing angle of the pedestal and the remote command are not the same, there will be a corresponding

angular error between the synchro shafts and a proportional ac output voltage from the CT rotors. The ac synchro error signal is then applied to the demodulator circuit. This circuit has as a reference input, the same 120-volt ac that energizes the TX in the remote source thus permitting synchronous demodulation of the ac error signal. The magnitude of the detected dc output is proportional to the magnitude of the ac error, and its polarity corresponds to the direction of the error. The dc error signal from the demodulator is stabilized with respect to gain and bandwidth in position amplifier in the servo control unit, whose compensation network has been switched to the slave mode. At the rate amplifier, the slave dc error signal becomes the actuating error signal and will drive the pedestal in a direction to make the pointing angles the same. The synchro shaft positions will then coincide and the ac error signals will go to zero. The tachometer feedback signal is introduced into the rate amplifier at the proper level for smooth operation of the pedestal in the slave mode. As the remote source is rotated, the pedestal will follow in a manner to continuously minimize the ac error signal and keep the pointing angles the same.

1.3.3 MANUAL POSITION MODE

The manual command unit continuously displays the pedestal position on 1:1 front-panel indicator dials and also provides for pedestal control in the manual position mode with handcrank-driven 1:1 synchro transmitters (TX's) in each axis.

For manual position mode operation, a 1:1 TX is provided in the manual command unit to generate manual position commands. The rotor shaft of this synchro is coupled to the indicator-dial gear train. When the MANUAL POSITION switch on the manual command unit front panel is actuated, the solid-state switches in the system servo control unit are operated to set up the signal inputs identical to the slave mode input. The manual command unit relays switch the pedestal CT stator leads from the slave input to the command transmitter. The transmitter can then be manually rotated by the front-panel handcrank for position control.

In the manual position mode, the pedestal control system functions as in the slave mode, except that it follows the handcrank commands instead of the position commands of the equipment connected to the slave input. In all modes other than the manual position mode, the front-panel dials indicate the present pedestal position.

1.3.4 AUTOTRACK MODE

In the autotrack mode, the feed derives an error signal that is proportional to the difference between the pointing angle of the autotrack antenna boresight and the direction of the RF signal source. This error signal is caused to amplitude modulate the received signal. The received signal is routed through a down converter to the tracking receiver. The receiver detects the amplitude modulation and presents a voltage proportional to the modulation magnitude and phase at the video output.

This output is routed to the tracking converter. The video signal passes to synchronous demodulators where the azimuth and elevation errors are separated and rectified. The demodulator references for decoding the error and the feed error encoding signals are generated in the scan code generator. The elevation dc error signal from the demodulator is amplified and fed into the servo control unit position amplifier. The azimuth axis is gain-corrected as a function of the secant $(\frac{1}{\text{cosine}})$ of the elevation angle. The cosine of the elevation angle function is generated by a potentiometer in the tracking converter. (Note that the servo loop is closed around the signal source, antenna, receiver, tracking converter, pedestal and control equipment and the pedestal mounting structure.) In passing through the position amplifier, the autotrack error signal gain versus frequency characteristics are controlled by the compensation networks which have been switched to autotrack by the mode selector. At the rate amplifier, the autotrack error signal becomes the actuating error signal that drives the pedestal in a direction to reduce the pointing error and dc error voltage to zero. The dc tachometer feedback signal is introduced into the rate amplifier at the proper level for smooth operation of the pedestal in the autotrack mode.

1.3.5 MANUAL RATE MODE

The manual rate signal, instead of the error signals from the position amplifier, can be switched into the rate amplifier. The manual rate signal is a positive or negative dc voltage from a potentiometer operated by a front-panel control. At the rate amplifier, this voltage is combined with the tachometer feedback voltage to become an actuating error signal which will rotate the pedestal at a speed determined by the potentiometer voltage setting. The polarity of the voltage determines the direction of rotation.

1.3.6 SECTOR SCAN MODE

Sector scan is a submode of the slave or manual position modes and the system must be operating in either one of these modes before scanning is enabled. With the system in either the slave or manual position mode, operation is as previously described. When scan is selected, the generator output is routed to the synchro demodulator in the servo control unit. The output causes the pedestal to rotate turning the shaft of the control transformers, thus generating a synchro error signal which continually attempts to cancel the generator signal. When the generator output changes polarity, the pedestal runs in the other direction. The center of scan is the position that is commanded by the slave input or the manual command unit.

1.3.7 STANDBY MODE

When the standby mode switch is actuated, control pulses to the power amplifiers are disabled, and the brakes are applied to the selected axis drive motor shaft. When the equipment is turned on by the POWER switch, the control system will always reset itself to the standby mode, ready for selection of the desired operating mode.

1.3.8 POSITION INDICATOR

The POSITION indicator displays elevation and azimuth angles on 1:1 front-panel indicator dials. The synchros which drive the indicators are connected to the TX stators and 115-volt ac, 60-Hz reference from the pedestal.

1.3.9 MODE LOGIC

The system modes are controlled by front-panel switches on the servo control unit and manual command unit together with digital logic circuits contained within the servo control unit.

TABLE 1-1. SYSTEM SPECIFICATIONS

Characteristic	Specifications
Stow Lock	
Azimuth	0°
Elevation	0°
Rated Speed	15°/sec (min)
Acceleration	15°/sec^2 (min)
Limit Switch Setting	
Azimuth	Slip rings
(Sector)	CW 0° to +2°
	CCW 0° to -2°
Elevation (Primary)	Up +85°, Down -5°
(Mechanical)	Up +186°, Down -6°
Readout Accuracy	±1°
Static Error	±0.1° (max)
Velocity Error	Kv = 333 (min)
Polarization	Horizontal
Antenna Gain	37.2 dB - 1687.1 and 1697.5 MHz
Preamplifier Noise Figure	1.6 dB (max)

1.4 EQUIPMENT SUPPLIED

Figure 1-2 lists the equipment supplied with the tracking pedestal set.

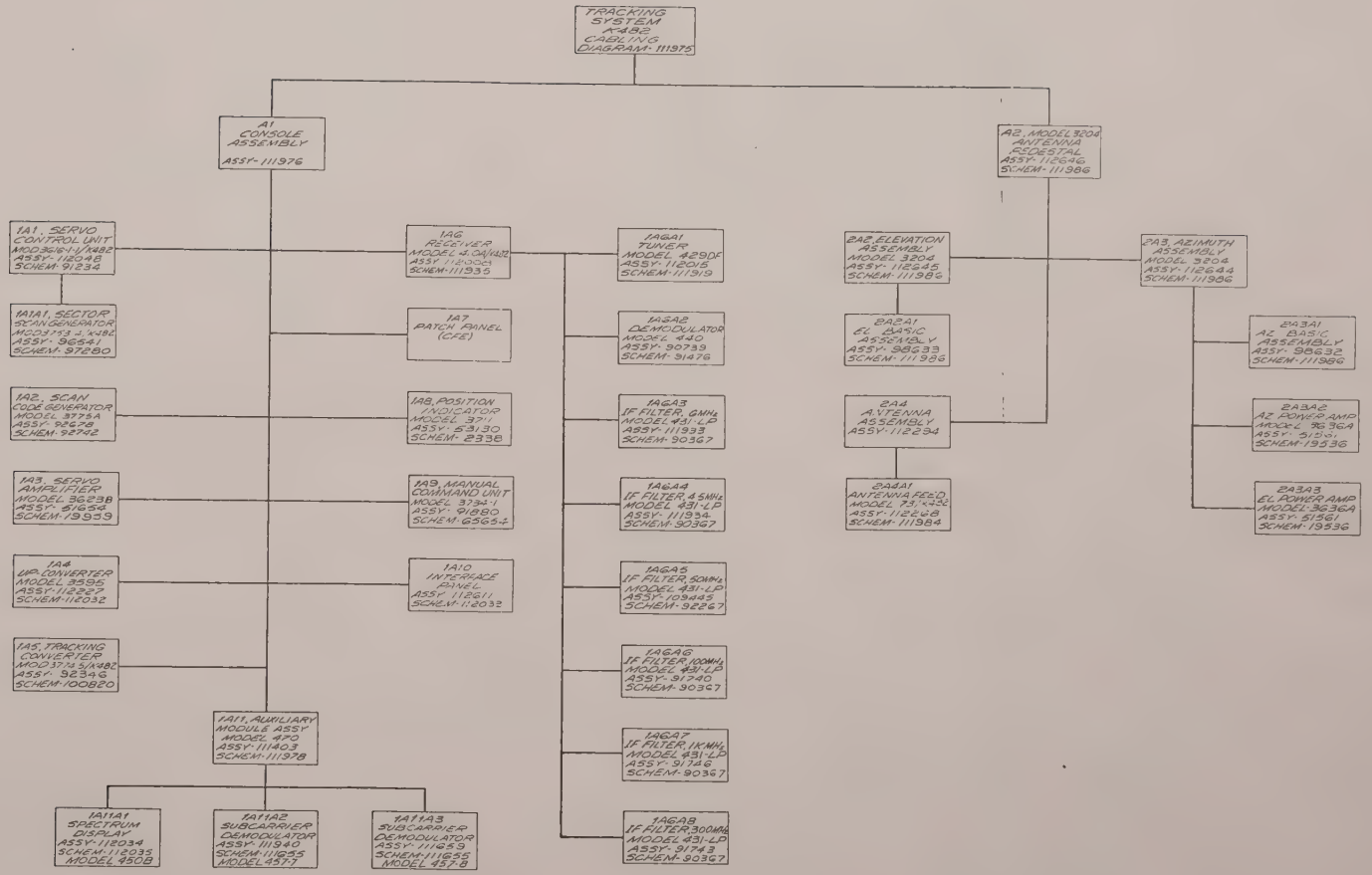

TRACKING SYSTEM K482 CABLING DIAGRAM - 111975
A1 CONSOLE ASSEMBLY ASSY - 111976
A2, MODEL 3204 ANTENNA PEDESTAL ASSY - 112646 SCHEM - 111986
1A1, SERVO CONTROL UNIT MODIFIED K482 ASSY - 112048 SCHEM - 91234
1A1A1, SECTOR SCAN GENERATOR MODIFIED K482 ASSY - 96541 SCHEM - 97280
1A2, SCAN CODE GENERATOR MODEL 3773A ASSY - 92678 SCHEM - 92742
1A3, SERVO AMPLIFIER MODEL 3623B ASSY - 81654 SCHEM - 19939
1A4 UP CONVERTER MODEL 3595 ASSY - 112227 SCHEM - 112032
1A5, TRACKING CONVERTER MODIFIED K482 ASSY - 92346 SCHEM - 100820
1A6 RECEIVER MODEL 4.0A/A32 ASSY - 112004 SCHEM - 111935
1A7 PATCH PANEL (CFE)
1A8, POSITION INDICATOR MODEL 3711 ASSY - 53130 SCHEM - 2338
1A9, MANUAL COMMAND UNIT MODEL 3794-1 ASSY - 91880 SCHEM - G5G5-1
1A10 INTERFACE PANEL ASSY 112611 SCHEM - 112032
1A11, AUXILIARY MODULE ASSY MODEL 470 ASSY - 111403 SCHEM - 111978
1A11A1 SPECTRUM DISPLAY ASSY - 112034 SCHEM - 112035 MODEL 450B
1A11A2 SUBCARRIER DEMODULATOR ASSY - 111940 SCHEM - 111645 MODEL 457-1
1A11A3 SUBCARRIER DEMODULATOR ASSY - 111659 SCHEM - 111655 MODEL 457-B
1A6A1 TUNER MODEL 429DF ASSY - 112015 SCHEM - 111919
1A6A2 DEMODULATOR MODEL 440 ASSY - 90739 SCHEM - 91476
1A6A3 IF FILTER, 6MHz MODEL 431-LD ASSY - 111933 SCHEM - 90367
1A6A4 IF FILTER, 4.5MHz MODEL 431-LD ASSY - 111934 SCHEM - 90367
1A6A5 IF FILTER, 50MHz MODEL 431-LD ASSY - 109445 SCHEM - 92267
1A6A6 IF FILTER, 100MHz MODEL 431-LD ASSY - 91740 SCHEM - 90367
1A6A7 IF FILTER, 1KMHz MODEL 431-LD ASSY - 91746 SCHEM - 90367
1A6A8 IF FILTER, 300MHz MODEL 431-LD ASSY - 91743 SCHEM - 90367
2A2, ELEVATION ASSEMBLY MODEL 3204 ASSY - 112045 SCHEM - 111986
2A2A1 EL BASIC ASSEMBLY ASSY - 98633 SCHEM - 111986
2A4 ANTENNA ASSEMBLY ASSY - 112294
2A4A1 ANTENNA FEED MODEL 79/K482 ASSY - 112268 SCHEM - 111984
2A3, AZIMUTH ASSEMBLY MODEL 3204 ASSY - 112644 SCHEM - 111986
2A3A1 AZ BASIC ASSEMBLY ASSY - 98632 SCHEM - 111986
2A3A2 AZ POWER AMP MODEL 963GA ASSY - 51551 SCHEM - 19936
2A3A3 EL POWER AMP MODEL 963GA ASSY - 51551 SCHEM - 19936

Figure 1-2. Nomenclature and Reference Designation K482

SECTION 2
SYSTEM INSTALLATION

2.1 GENERAL

Installation of the control system and pedestal assembly will conform to standards designated by the installing agency and customer as to unit location and type of installation. This section contains suggestions and factors to consider before installing the units. Close adherence to these suggestions will assure a more satisfactory performance of the equipments. For information concerning antenna feed installation, refer to the Series 3200 Tracking Pedestal instruction manual.

2.2 UNPACKING AND INSPECTION

Exercise caution when unpacking the units. Carefully open each carton and inspect each unit for damage. If a claim for damage is to be made, save the packing material and carton to substantiate the claim. File the claim with the carrier and notify the nearest Scientific-Atlanta sales representative immediately. Do not return the unit until shipping instructions have been received from the factory.

After all units have been removed from the cartons, check for small components that may have been wrapped separately. Compare units received against the shipping list. If possible, save all packing material and cartons for future storing or reshipments.

2.3 INSTALLATION CHECKOUT

After the subsystem has been physically installed (see figures 2-1 and 2-2) and cables have been connected, the following step-by-step checks should be made to make sure that all connections are correct and that there are no mechanical or electrical interferences existing.

a. Visually inspect the pedestal and antenna area to make sure there is no construction and/or packing material left on or near the antenna.

b. Recheck the pedestal leveling vials in the elevation section. Adjust the jacks if necessary.

c. Tighten all cable connectors where they are attached to the pedestal and where they enter the feed (the feed cables can be checked when the antenna is depressed).

d. Inspect the routing of all cables on and near the pedestal. None should be pinched or sharply bent. All cables should be clamped at intervals sufficient to remove strains from the cable connectors.

e. Refer to table 2-1 and close the interlocks on the pedestal.

WARNING

DURING THE PEDESTAL UNSTOWING PROCEDURE, MAKE SURE THAT POWER IS NOT INADVERTENTLY APPLIED TO THE PEDESTAL BY SOMEONE AT THE CONTROL LOCATION. TO PREVENT UNEXPECTED PEDESTAL MOVEMENT, PLACE THE RUN-SAFE SWITCH ON THE CONNECTOR PANEL IN THE DISABLE POSITION.

TABLE 2-1. FASTENER DESIGN STANDARDS

Note

For SAE grade 5 hex head cap screws (ASTM A-325) and socket head cap screws.

Fastener Size	Tightening Torque (Foot-Pounds) Dry	Lubricated or Cad Plated
1/4-20	8	6
5/16-18	17	13
3/8-16	30	23
7/16-14	50	35
1/2-13	75	50
9/16-12	110	80
5/8-11	150	110
3/4-10	260	200
7/8-9	400	300
1-8	580	440
1-1/4-7	1120	840

2.4.1 CABLE CONNECTIONS

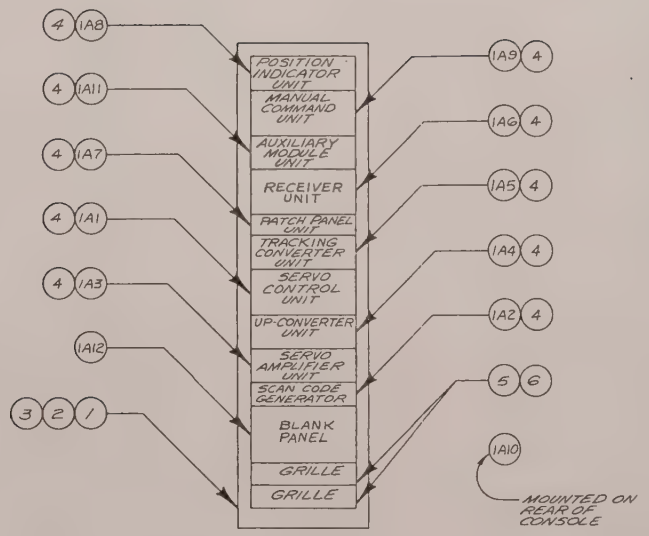
The following procedure gives general information for cable connections. For detailed cable routing and connections, refer to figure 2-2, cabling diagram.

a. Place the RUN-SAFE switch on the pedestal to SAFE position.

b. Inspect all connectors on the pedestal connector plate and console connector plate. If necessary, clean with dry air.

c. Make initial cable connections at the pedestal connector plate.

d. Run cables from the pedestal to the console connector plate and make final connections.



NOTE:
1. CONSOLE PAINTED OPTIMA SKY BLUE WITH DEEP CHARCOAL BEZEL.

ITEM OR FIND NO	QTY REQD	S-A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO
1A12	1	P754	BLANK PANEL	7IN. X 3/16"	
1A11	1	112063	AUXILIARY MODULE ASSY		
1A10	1	112611	INTERFACE PANEL ASSY		
1A9	1	91880	MANUAL COMMAND UNIT ASSY		
1A8	1	53130	POSITION INDICATOR ASSY		
1A7	1	N/A	PATCH PANEL ASSEMBLY	CFE	
1A6	1	112008	RECEIVER ASSEMBLY		
1A5	1	92346	TRACKING CONVERTER ASSY		
1A4	1	112227	UP-CONVERTER UNIT ASSEMBLY		
1A3	1	51654	SERVO AMPLIFIER ASSY		
1A2	1	55974	SCAN CODE GENERATOR ASSY		
1A1	1	112048	SERVO CONTROL UNIT ASSEMBLY		
6	1	N/A	BLOWER		MODEL-2E408A
5	2	N/A	GRILLE	7IN	OPTIMA G319
4	20	N/A	RACK SLIDES		MODEL-110QD-24-2
3	9	N/A	RETRACTOR, CABLE		MODEL-CRS-25
2	1	111975	CABLES		
1	1	N/A	CONSOLE		OPTIMA R-701924

PARTS LIST

Figure 2-1. Console Assembly K482

SECTION 3
OPERATION

3.1 GENERAL

The procedures for operating the tracking pedestal sets are outlined in this section.

3.2 CONTROLS AND INDICATORS

3.2.1 SERVO CONTROL UNIT (SERIES 3616)

The servo control unit operating controls and indicators are listed in table 3-1. Front-panel mounted fuses are clearly identified on the front panel. Refer to figure 3-1 for control and indicator locations.

TABLE 3-1. FRONT-PANEL CONTROLS AND INDICATORS, SERIES 3616 SERVO CONTROL UNIT

Ref Desig	Name	Function
	MANUAL MODE SELECTION Group	
S7 (El) S2 (Az)	STANDBY Switches	Manually places the system into STANDBY
S8 (El) S3 (Az)	READY Switches	Manually places the system into READY mode
S9 (El) S4 (Az)	AUTOTRACK Switches	Manually places the unit in the AUTOTRACK mode
S10 (El) S5 (Az)	MANUAL RATE Switches	Manually places the unit in the MANUAL RATE mode
S11 (El) S6 (Az)	SLAVE Switches	Manually places the unit in the SLAVE mode
	AUTO MODE SELECTION Group (Model 3616-1-1 & Model 3616-2-1 only)	
S12	AUTO ACQ Switch	When energized, allows the unit to transfer from any mode other than STANDBY to the AUTOTRACK mode upon receiving a target

TABLE 3-1. FRONT-PANEL CONTROLS AND INDICATORS, SERIES 3616 SERVO CONTROL UNIT-continued

Ref Desig	Name	Function
S13	RATE MEMORY Switch	When energized, transfers the unit to RATE MEMORY immediately following target loss
S14	SLAVE Backup Switch	When energized, transfers the unit to the SLAVE mode immediately following target loss or RATE MEMORY timeout
S15	MAN POSITION Backup	When energized, transfers the unit to the manual position mode immediately following target loss or RATE MEMORY timeout
	STATUS Indicator Group	
DS1	LOCKON Indicator	Indicates that a signal of sufficient signal strength is available for autotracking
DS2	JOYSTICK/SCU Indicator	Split indicator, indicates that either a remote joystick (optional) or the servo control unit has control of the antenna control system
DS3	PEDESTAL/REMOTE Indicator	Split indicator, illuminates if a remote control unit or a pedestal remote control unit maintains control of the antenna control system
	EL LIMIT Indicators	
DS8	UP	Neon indicator, illuminates if the pedestal-antenna structure is in the UP travel limit
DS9	DOWN	Neon indicator, illuminates if the pedestal-antenna structure is in the DOWN travel limit
	AZ SECTOR Indicators	
DS7	CCW	Neon indicator, illuminates if the pedestal-antenna structure is in the counterclockwise sector of rotation

TABLE 3-1. FRONT-PANEL CONTROLS AND INDICATORS, SERIES 3616 SERVO CONTROL UNIT-continued

Ref Desig	Name	Function
DS6	CW	Neon indicator, illuminates if the pedestal-antenna structure is in the clockwise sector of rotation
	RATE Controls	
R2	ELEVATION RATE Control	Determines the elevation rate when the elevation axis is in the MANUAL RATE mode of operation
R1	AZIMUTH RATE Control	Determines the azimuth rate when the azimuth axis is in the MANUAL RATE mode of operation

3.2.2 TRACKING CONVERTER (SERIES 3774)

The tracking converter operating controls are listed in table 3-2.

TABLE 3-2. CONTROLS AND INDICATORS, SERIES 3774 TRACKING CONVERTER (AUTOTRACK SYSTEM)

Ref Desig	Name	Function
S1	TRACKING POWER	When energized, applies primary power to the scan code generator. Also applies +28V and ±15V to their distribution points. The lamps in the backlighted switch illuminates when the switch is energized
S2	RF SYSTEM POWER	When energized, applies primary power to the power supply transformer primary windings and to the receiver primary power jacks
S4		Not used
S5		Not used
S6		Not used

TABLE 3-2. CONTROLS AND INDICATORS, SERIES 3774 TRACKING CONVERTER (AUTOTRACK SYSTEM)-continued

Ref Desig	Name	Function
S7	ACQUISITION LEVEL	When energized, the acquisition level is determined by a control on the test and adjustment card. Two controls are used, one for each polarization. The PRESET lamps illuminate. When de-energized, the front-panel ACQUISITION LEVEL control is selected and the MANUAL lamps illuminate
	ACQUIRE INDICATOR	Illuminates when the RF signal level amplitude is sufficient to permit automatic tracking
	LOSS INDICATOR	Illuminates when the RF signal level amplitude is not sufficient to sustain automatic tracking

3.2.3 MANUAL COMMAND UNIT (MODEL 3734-1)

The manual command operating controls and indicators are listed in table 3-3.

TABLE 3-3. CONTROLS AND INDICATORS, MODEL 3734-1 MANUAL COMMAND UNIT

Ref Desig	Name	Function
S1	ELEVATION MANUAL POSITION	When energized, selects a manual position operating mode for the elevation axis. The lamp illuminates when the switch is energized
S2	AZIMUTH MANUAL POSITION	When energized, selects a manual position operating mode for the azimuth axis. The lamp illuminates when the switch is energized

TABLE 3-3. CONTROLS AND INDICATORS, MODEL 3734-1
MANUAL COMMAND UNIT-continued

Ref Desig	Name	Function
	ELEVATION MANUAL DRIVE	When S1 switch is energized and the handwheel spring is compressed, the handwheel may be used to center the elevation axis turntable position
	AZIMUTH MANUAL DRIVE	When S2 is energized and the handwheel spring is compressed, the handwheel may be used to control the azimuth turntable position
	ELEVATION INDICATOR	The pointer of the dial indicator presents a visual readout of the elevation axis position when S1 is not energized. When operating in the MANUAL POSITION mode, the indicator reads the commanded position
	AZIMUTH INDICATOR	Presents a visual readout of the azimuth axis position when S2 is de-energized. When S2 is energized, the pointer indicates the commanded position

3.3 OPERATION

3.3.1 START PROCEDURE

The procedure for energizing the Series 3616 Servo Control Unit is as follows:

a. Remove all front-panel mounting fuses and inspect for continuity.

b. Press the POWER switch to apply power to the unit. On some models of the servo control unit, the POWER switch has a hinged cover to prevent accidental removal of power when unit is operating. To apply power, swing the hinged cover out and press the POWER switch. This applies ac power to the servo control unit power supply and energizes the overall system.

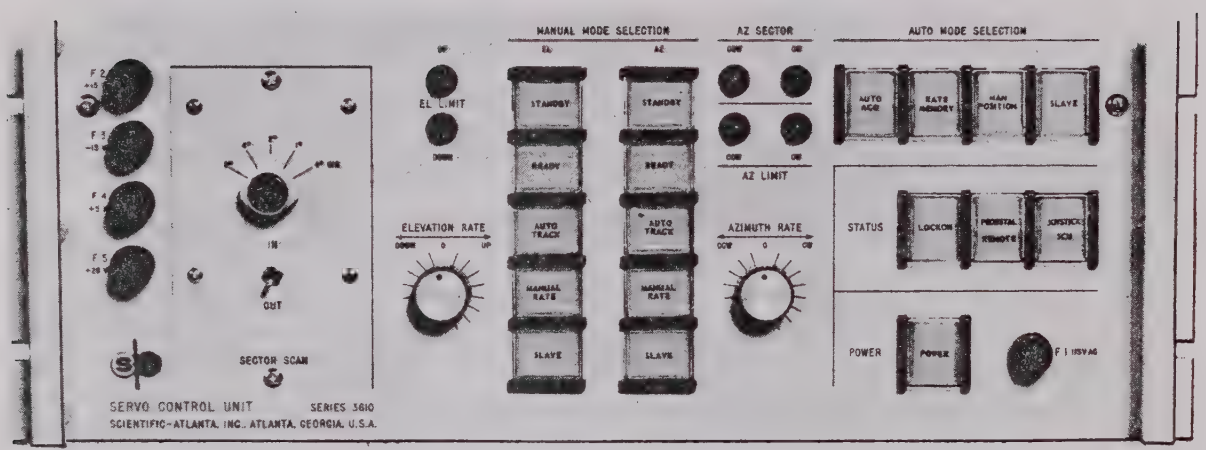


Figure 3-1. Controls and Indicators
Model 3616 Servo Control Unit

3.3.2 TURN-OFF PROCEDURE

The servo control unit may be turned off or de-energized either of two ways:

a. By removing power from the unit externally, such as by placing the system POWER switch in the OFF position or by otherwise removing power from the entire system.

b. By turning the servo control unit off. To do this, simply press the POWER switch once. On some models the cover must be opened to do this.

3.3.3 SERVO SYSTEM OPERATING MODES AND PROCEDURES

There are five basic servo control unit modes of operation. Each is discussed at two levels: a descriptive definition of each operating mode, followed by the procedure or procedures for operating in each particular mode. The modes of operation are:

a. Standby

b. Ready

c. Autotrack

d. Manual Rate

e. Slave

3.3.3.1 Standby Operating Mode. In the standby mode, the servo control unit is effectively idling and requires further operator commands to place the unit in the active operating status. Brakes are applied to the antenna in this mode.

3.3.3.2 Standby Mode Operating Procedure. When the POWER switch is turned on, the system will automatically be in the standby mode. To place the servo control unit in the standby mode from another mode, merely press the standby mode switches (Az and El). To transfer from standby to another mode, refer to the operating mode discussion and procedure for the desired mode.

3.3.3.3 Ready Operating Mode. In the ready mode, the unit has received push-button mode instructions from the operator and is waiting for certain conditions indicated by command signals from other units in the system to occur before transferring to one of the other modes, usually autotrack or standby. The ready mode

differs from the standby mode in that the unit will do nothing until manually commanded to do so when operating in the standby mode. While it is inactive in the ready mode, the unit has either just been activated, is waiting for conditions to return to a status allowing active operation, or has been commanded to a submode and is waiting for conditions to reach a preselected status before going into an active condition. In the case of the unit being in a submode, the unit will transfer to either standby or autotrack, depending on whether the preselected conditions are reached.

3.3.3.4 Ready Operating Mode Procedure. In order to manually place the system in the ready mode, merely depress the azimuth and elevation ready mode pushbuttons. The system will transfer from the previous mode directly into the ready mode, brakes will be applied to the pedestal, and the system will await further operator commands or automatic commands from the automatic logic contained in some models.

3.3.3.5 Autotrack Operating Mode (Autotrack System). In the autotrack mode, if the antenna is receiving RF energy from a source not on the antenna boresight axis, a video signal is produced by the receiver which contains the tracking error information. This is processed in another unit in the system and used to drive the azimuth and elevation axes to reduce the target and misalignment to zero. Should the received signal at the antenna drop to below the preset level, indicating signal loss, the servo control unit may transfer to an operating submode. The submodes may also be used during a signal acquisition and signal reacquisition phase. Two basic submodes are contained in the servo control unit; these are discussed in the following paragraphs.

Automatic Acquisition: In this submode, the system will automatically transfer to the autotrack mode upon reception of an RF signal. If the antenna scanning velocity is high at the time the signal is detected, direct transfer to the autotrack mode will not result in antenna signal source lock-on due to the relatively narrow beamwidth, deceleration time, and response time of the servo. Under these conditions, the servo control unit will enter an intermediate mode called position memory. In position memory, the position at which the target was acquired is electronically stored. The servo control unit automatically commands the antenna to return to this acquire point, and then transfers to the autotrack mode if the receiver signal reappears. If the receiver signal does not reappear, the system transfers back to the mode it was in before transferring to autotrack.

Automatic Reacquisition: If, after having been locked on in autotrack, the signal drops below a preset level, the servo control unit is switched to another intermediate mode called rate memory, provided rate memory has been selected. Rate memory maintains a tracking velocity at the value in effect immediately prior to loss of track. The system remains in rate memory for a selectable period of time up to 1 minute. If the signal does not return during this period, the system will automatically return to either slave or manual position depending on the backup mode status. If neither slave nor manual position has been selected as a backup mode, the system will return to the ready mode and await further operator decision. In any event, after rate memory times out and the system has returned to either slave, manual position, or ready, the system will remain in that particular mode until the operator commands the system to do otherwise. If rate memory has not been selected, the system will transfer directly to either manual position or slave or remain in autotrack if the signal drops below a preset loss level.

3.3.3.6 Autotrack Operating Mode Procedure (Autotrack System). There are two ways of obtaining autotrack mode. First, the system may be manually placed in the autotrack mode by simply depressing the autotrack mode selector front-panel switches. If this technique is used, the system will remain in the autotrack mode independent of the presence of an autotrack target. The second method of obtaining the autotrack mode is through the automatic acquisition phase. To obtain autotrack through this phase, depress the auto acquisition mode pushbutton located on the front panel and place the system in a mode other than standby. When this method is used, the servo control unit will automatically transfer from the mode it is presently in to the autotrack mode upon the presence of a sufficiently high signal strength from the receiver.

3.3.3.7 Automatic Reacquisition Operating Procedure (Autotrack System). Prior to a tracking exercise, the operator must determine which backup mode should be used in the event that a signal is lost and auto reacquisition is desired. In order to use rate memory as a primary backup mode, simply depress the RATE MEMORY pushbutton located on the front panel of the servo control unit. When depressed, the upper half of this pushbutton will illuminate white. In the event that signal loss occurs, the system will automatically transfer from the autotrack mode to the rate memory mode of operation. When in the rate memory mode of operation, the lower half of the RATE MEMORY pushbutton will illuminate green, indicating that the system is presently in the rate memory mode of operation. After rate memory timeout, the system will return to the ready mode of operation and the READY pushbuttons will illuminate green, indicating that the system is in the ready mode.

If the operator desires further backup aid, he may simply depress either the manual position or the slave backup mode selector switch. When depressed, these selector switches will illuminate white, indicating that the particular backup mode has been selected. Upon timeout from rate memory, the system will transfer directly to either manual position or slave, depending upon which has been selected. If the operator does not desire rate memory, but desires to transfer directly from autotrack to either manual rate or slave upon loss of signal, he may simply depress the secondary backup mode switches but not the rate memory selector switch. The system will then transfer directly from autotrack to either manual position or slave upon loss of signal. After transferring, the front-panel manual mode selector switches will illuminate green, indicating the particular mode that the system has transferred to.

3.3.3.8 Manual Rate Operating Mode (Autotrack System). In the manual rate operating mode, the pedestal velocity is controlled by front-panel manual rate control knobs (see figure 3-1 for location). In this operating mode, commands from the front-panel manual rate control knobs are compared with tachometer feedback voltages to assure smooth and accurate velocity commands to the pedestal.

3.3.3.9 Manual Rate Operating Mode Procedure. To place the system in the manual rate operating mode, simply depress the elevation and/or the azimuth manual rate mode pushbutton located on the front panel. These mode pushbuttons will illuminate green, indicating that the system is in the manual rate mode. The antenna pedestal structure will then move at a velocity proportional to the deviation from zero of the manual rate control knobs.

3.3.3.10 Slave Operating Mode. In the slave operating mode, an external TX is required to drive the pedestal. This external TX should be connected into the servo amplifier unit (see the Model 3623B Servo Amplifier and Models 3635A and 3636A Power Amplifier instruction manual for proper connection). In this mode, the pedestal will point at the position commanded by the external TX.

3.3.3.11 Slave Mode Operating Procedure. After connecting an external synchro transmitter into the system, merely depress the elevation and/or azimuth slave mode operating pushbuttons. These pushbuttons will illuminate green when activated, indicating that the system is in the slave mode of operation. The pedestal will then point at the angle commanded by the external synchro transmitter.

3.3.3.12 Manual Position Operating Mode. In order to operate in the manual position mode, the manual command unit must be used. Essentially, this manual command unit is identical to an external synchro transmitter with the exception that the synchro transmitter is located in the manual command unit. In this mode of operation, the pedestal is slaved to the synchro transmitter located in the manual command unit and will point in the direction commanded by this transmitter.

3.3.3.13 Manual Position Operating Procedure. To operate in the manual position mode, the manual command unit must be connected to the system. Depress the mode selector pushbuttons located on the manual command unit. When depressed, these pushbuttons will illuminate green, indicating that the system is in the manual position mode of operation. The operator may then position the pedestal by means of the front-panel handwheels located on the manual command unit.

3.3.4 AUTOMATIC TRACKING MODE OPERATING INSTRUCTIONS (AUTOTRACK SYSTEM)

The tracking converter provides controls and indicators for the RF portion of the antenna system and also provides the antenna derived servo error signals. For proper operation of this unit, the antenna pedestal must be pointed at the RF source within the acquisition cone angle of antenna, and the RF system must be properly installed and operating.

3.3.4.1 Basic Operation. The tracking converter is operated as follows:

a. Press the TRACKING POWER button and observe that the pushbutton is illuminated.

b. Press the RF SYSTEM POWER button and observe that the pushbutton is illuminated. When the RF signal is attenuated or removed, the carrier LOSS indicator should illuminate. Adjustment of the carrier loss level may be necessary if this does not occur (see section 5).

c. When the RF signal is increased above the receiver noise level, the ACQUIRE indicator should light. The level at which acquisition occurs is determined by the MANUAL ACQUISITION LEVEL control on the front panel, or the PRESET control (internal service adjustment) as selected by the front panel operator/indicator.

d. Using one of the manual modes of the servo control unit, move the antenna off boresight and observe that the tracking error signals are displayed on the AZIMUTH ERROR and ELEVATION ERROR meters.

3.3.4.2 Acquisition and Loss Indicators and Controls. Operation of the carrier acquisition and carrier loss indicators and controls is described below. These controls are also used to control mode logic functions of automatic acquisition or rate memory.

a. The antenna should be positioned so that maximum signal is received as indicated by the receiver signal strength meter.

b. The ACQUIRE threshold level is determined by the front-panel MANUAL ACQUISITION level control (clock potentiometer) when the MANUAL-PRESET ACQUISITION switch is set to MANUAL.

c. The ACQUIRE threshold level is determined by a preset value (see section 5) when the MANUAL-PRESET ACQUISITION switch is set to PRESET.

3.3.4.3 Automatic Tracking (Autotrack System).

a. Using the MANUAL RATE or SLAVE modes, direct the antenna in the direction of the signal emitted from the target which is to be tracked.

b. Switch the receiver to the signal frequency as indicated by the tuner switch.

c. Energize the AUTOTRACK switch on the servo control unit. The LOCKON indicator should illuminate and automatic tracking commence.

3.3.4.4 Backup Mode Operation (Autotrack System). RATE MEMORY, and MANUAL POSITION or SLAVE modes may be used as backup modes and take effect immediately if the tracking signal is lost after automatic acquisition tracking. The upper half of the selected backup mode switch will illuminate when the switch is energized. When the backup mode becomes effective, the lower half will illuminate. During the RATE MEMORY timing cycle, typically 1 minute, the last tracking rate will be maintained during the time cycle. At the end of the cycle, if re-acquisition has not occurred, the operating mode will switch to either MANUAL POSITION or SLAVE as selected. If a backup mode has not been selected, operation will revert to the READY mode. If at any time the tracking signal is re-acquired at levels sufficient to energize the ACQUIRE lamp, automatic tracking will resume.

SECTION 4
THEORY OF OPERATION

For detailed operation of the circuitry in the tracking system, the reader is referred to the individual unit instruction manuals.

A description of the scan code single channel monopulse tracking system technique is contained in the technical paper at the end of this manual.

SECTION 5
MAINTENANCE

5.1 GENERAL

Contained in this section is preventive maintenance information for the mobile telemetry station antenna subsystem. For specific maintenance procedures, references are made to the instruction manuals for the units involved.

5.2 PREVENTIVE MAINTENANCE

Preventive maintenance of the subsystem consists of inspection, cleaning, and trailer brake adjustment. Maintenance should be performed on a regular schedule, typically every 90 days, and particularly before a mission is to be run and when the trailer is to be moved.

5.2.1 EQUIPMENT REQUIRED

No special equipment is required for preventive maintenance. Use the following list as a guide in the procurement of common items.

Wiping rags
Cleaning solvent
Common hand tools
Flashlight
Inspection mirror
Air hose (15 psi max) for cleaning purposes
Grease gun
Air line (80 lb/in^2 min) for tire inflation
Wheel lug wrench (13/16 inch)
Hydraulic brake fluid, heavy duty, 1 pint

5.2.2 VISUAL INSPECTION

a. Inspect all units in the subsystem for signs of physical damage.

WARNING

MAKE SURE THAT POWER IS REMOVED FROM THE PEDESTAL AND THAT THE RUN-DISABLE SWITCHES ON THE PEDESTAL AND ON THE LOCAL CONTROL BOX ARE SET TO THE DISABLE POSITION.

b. Look for lubricant leaks, rust spots, signs of overheating, etc.

c. Check the trailer tires for condition and pressure.

d. Make sure that all wheel lug nuts are tight.

e. Test the trailer lights by connecting the electrical cable to the trailer and operating the appropriate controls in the prime mover.

f. Check the fluid level in the brake actuator master cylinder. Refill as required.

g. Inspect the hydraulic system for leaks and damaged lines if necessary. Repair any damage as soon as possible.

h. Wipe the trailer reflectors and lamp lenses clean with a soft, damp rag.

i. Remove the sheet-metal cover from the trailer brake actuator and clean the hydraulic plunger slot and bolt.

SECTION 6
RECOMMENDED SPARES

6.1 GENERAL

This section contains a one-year recommended spares list. Minimum downtime was considered when compiling this list. The individual unit manuals in the K482 system contain descriptions of all electrical components and parts lists.

6.2 ORDERING PARTS

When ordering parts from Scientific-Atlanta, Inc., always include the S-A part number, part description, unit name, subassembly name, part manufacturer, manufacturers' part number, and Scientific-Atlanta's job number (such as K482 PRICES GIVEN ARE GOOD FOR 90 DAYS AFTER DATE OF MANUAL.

RECOMMENDED SPARES LIST Reference Number 33S0050R

MODEL 410A/K482 NAME BASIC RECEIVER UNIT

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	BASIC RECEIVER UNIT	NA	410A/K482	112008	1	10110	0
2	POWER SUPPLY 5820 350 7893	472.00	402A	91479	1	10110	1
3	60MHz IF AMP.	247.00	403A	111924	1	10110	1
4	2nd LOCAL OSC.	392.00	404C	111927	1	10110	1
5	10 MHz IF AMP.	152.00	405B	111995	1	10110	1
6	AM DEMODULATOR 5820 350 7898	197.00	406A	90735	1	10110	1
7	VIDEO AMPLIFIER 5820 350 7900	267.00	408A	91808	1	10110	1
8	VIDEO FILTER	192.00	409A	90721	1	10110	1
9	METER, TUNING 6625 488 9401	34.00	64797	64797	1	10110	1
10	METER, SIG. STRENGTH 6625 488 9400	34.00	64817	64817	1	10110	1
11	METER, OUTPUT 6625 449 2842	34.00	64818	64818	1	10110	1
12	METER	34.00	64819	64819	1	10110	1

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 450B NAME SPECTRUM DISPLAY UNIT

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	TRANSFORMER	71.50	97066	97066	1	10110	1
2	INTEGRATED CIRCUIT	2.00	78715	CA3028A	2	79089	1
3	HIGH VOLTAGE MODULE	385.00	100916	100916	1	10110	1
4	TRANSISTOR	4.70	77148	2N3251	2	04713	1
5	CATHODE RAY TUBE	90.00	79098	SC5082-P2	1	80368	1
6	CRYSTAL	12.00	CR-25B/U 500 kHz	CR-25B/U 500 kHz	1	10110	1
7	CAPACITOR 100MF 20V	3.90	70667	CS13BE107K	1	80183	1
8	TRANSISTOR	3.60	77147	2N3947	5	04713	2

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL K482 NAME R. F. EQUIPMENT

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	TUNER 429DF	1600.00	112015	112015	1	10110	
2	DEMOD 440	325.00	90739	90739	1	10110	
3	431-LP-6.0 MHz	225.00	111933	111933	1	10110	
4	431-LP-4.5 MHz	225.00	111934	111934	1	10110	
5	431-LP-.05 MHz	275.00	109445	109445	1	10110	
6	431-LP-.1 MHz	275.00	91740	91740	1	10110	
7	431-LP-1.0 MHz	225.00	91746	91746	1	10110	
8	431-LP-.3 MHz	225.00	91743	91743	1	10110	
9	457/7	1100.00	111659	111659	1	10110	
10	457/8	1100.00	111940	111940	1	10110	

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3204/K482 NAME TRACKING PEDESTAL

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	MOTOR 3HP	1340.00	19841-2	19841-2	2	10110	1
2	BRAKE ASSY. EL.	300.00	39639	39639	1	10110	1
3	BRAKE ASSY. AZ.	300.00	39645	39645	1	10110	1
4	TACH ASSY.	222.00	20931	20931	2	10110	1
5	SWITCH LIMIT AZ.	262.00	44885	44885	1	10110	1
6	SWITCH LIMIT EL.	262.00	44862	44862	1	10110	1
7	SWITCH TOGGLE	2.30	72907	9801	2	74545	1
8	SWITCH	1.80	72956	V3-601	10	91929	3
9	SWITCH	1.60	72888	11SM1	8	91929	3
10	ACTUATOR, SWITCH	1.00	72923	JS-5	8	91929	3
11	ACTUATOR, SWITCH	1.00	72924	JV-5	4	91929	2
12	ACTUATOR, SWITCH	1.50	72926	JV_82	3	91929	2
13	STOW PIN, AZIMUTH	10.00	71552	71552	1	10110	1
14	STOW PIN, ELEVATION	7.75	71551	71551	2	10110	1
15	SWITCH, BRAKE	2.60	72906	8822K20	2	04009	1
16	SYNCHRO	88.00	81184	23TX6		10110	2
17	SYNCHRO	88.00	81182	23CT6		10110	2

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3616-1-1/K482 PN112048 NAME SERVO CONTROL UNIT

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	INDICATOR UNIT	20.00	49859	49859	1	10110	1
2	INDICATOR UNIT	25.00	90778	90778	1	10110	1
3	INDICATOR UNIT	25.00	90777	90777	1	10110	1
4	INDICATOR UNIT	1.50	71407	R118-323	6	72765	2
5	FUSE, 5A, 3AG, SB	1.25	71232	313005	1	75915	Box of 5
6	FUSE, 0.5A, 3AG, SB	1.25	71217	313000.5	3	75915	Box of5
7	FUSE, 3A, 3AG, SB	1.25	71228	313003	1	75915	Box of 5
8	SWITCH ASSY.	35.00	90791	90791	1	10110	1
9	SWITCH UNIT	35.00	90792	90792	2	10110	1
10	SWITCH UNIT	35.00	90774	90774	8	10110	2
11	SWITCH UNIT	45.00	90776	90776	2	10110	1
12	SWITCH UNIT	35.00	90775	90775	2	10110	1
13	FUSE HOLDER	1.00	71249	HKP	5	71400	2
14	RELAY, 24VDC	5.00	75528	T163-4C	5	70309	2
15	CONNECTOR	3.00	78225	251 22 3016 0	31	71785	6
16	TRANSISTOR	2.50	78017	2N3055	2	79089	2
17	POTENTIOMETER	32.00	71712	42-900	2	12697	1
18	DEMOD. SHORTING	25.00	92337	92337	2	10110	1
19	EXTENDER CARDS	25.00	47209	47209	2	10110	5
20	CAPACITOR 1100mfd	2.00	75221	39D	1	80183	1
21	CAPACITOR 2100mfd	2.50	76731	39D	2	80183	2

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3616-1-1/K482 PN112048 NAME SERVO CONTROL UNIT

SHEET 2 OF 2

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
22	POWER SUPPLY	55.00	65697	65697	1	10110	1
23	LAMP	5.00	71402	327	34	24446	Box of 10
24	MANUAL SELECT	154.00	65601	65601	2	10110	1
25	FAULT LOGIC	238.00	57418	57418	2	10110	1
26	SWITCH DRIVER	129.00	65902	65902	3	10110	1
27	LAMP DRIVER	123.00	65596	65596	2	10110	1
28	AUTO ACQUIRE	207.00	65603	65603	1	10110	1
29	AUTO REACQUIRE I	172.00	65605	65605	1	10110	1
30	AUTO REACQUIRE II	252.00	65607	65607	1	10110	1
31	REGULATOR 5 VOLTS	85.00	65688	65688	1	10110	1
32	POWER SUPPLY	112.00	65702	65702	1	10110	1
33	RATE AMPLIFIER	237.00	112045	112045	2	10110	1
34	RATE MEMORY	214.00	65921	65921	2	10110	1
35	POSITION MEMORY	162.00	112044	112044	2	10110	1
36	POSITION AMP.	162.00	112046	112046	2	10110	1
37	SYNCHRO DEMOD.	172.00	112047	112047	2	10110	1
38	EXTERNAL COMP.	212.00	91229	91229	2	10110	1
39	LIMIT CARD	177.00	112043	112043	1	10110	1

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3623, 51654 NAME SERVO AMPLIFIER

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	SERVO CONTROL AMP. 5820 255 2649	612.00	2122	2122	2	10110	1
2	PC COPM. & PULSE GEN. 5820 255 2650	200.00	35488	35488	2	10110	1
3	PC RAMP GENERATOR 5820 255 2651	168.00	35490	35490	2	10110	1
4	LAMP, 18V, 0.25A 6240 196 4467	5.00	74390	433	2	24446	Box of 10
5	CURRENT LIMITER 5820 496 1985ZX	512.00	19783	19783	1	10110	1
6	PC ASSY CURRENT LIMITER	100.00	18923	18923	2	10110	1
7	FUSE, 5A, 3AG, SB	1.25	71232	313005	1	75915	Box of 5
8	FUSE, 3A, 3AG, SB	1.25	71228	313003	2	75915	Box of 5
9	FUSE HOLDER	1.00	71249	HKP	3	71400	1

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3636, 51561 NAME SCR POWER AMPLIFIER

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	SCR ASSY	2360.00	51574	51574	2	10110	1
2	CHOKE ASSY	162.00	17214	17214	2	10110	1
3	DIODE	3.50	71140	1N3212	4	80211	2
4	DIODE	3.50	71141	1N3212R	4	80211	2
5	FAN	15.00	74200	WS-2107F	2	99743	1
6	FILTER	15.15	71169	10JX34	2	80183	1
7	FILTER	120.00	71172	40JX11	4	80183	2
8	CAPACITOR	1.00	70680	AXCK70AW	28	00656	6
9	RELAY, 110VDC	14.00	75525	KRP14DG	4	77342	2
10	RELAY, 24VDC	9.50	71796	KRP5DG	2	77342	1
11	RELAY, 110VDC	11.50	71795	KRP5D	2	77342	1
12	THYRECTOR	15.00	75049	6RS25SA6D6	6	24446	2
13	THYRECTOR	19.00	75050	6RS25SA9D9	2	24446	1
14	FUSE, 5A, 3AG, SB	1.25	71232	313005	2	75915	Box of 5
15	FUSE, 40A	12.00	74230	FRN-40	4	71400	Box of 10
16	FUSE HOLDER	1.00	74239	10982-H11A2	4	15605	1

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3711, 53130 NAME POSITION INDICATOR

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	DIAL GLASS	2.50	1825	1825	2	10110	2
2	BEZEL	3.00	64168	64168	2	10110	2
3	SYNCHRO	88.00	78313	78313	2	10110	1
4	FUSEHOLDER	1.00	71249	HKP	1	71400	1
5	FUSE, 2.5A, 3AG, SB	1.45	71226	313002.5	1	75915	Box of 5

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3734-1, 91880 NAME MANUAL COMMAND UNIT

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	SYNCHRO ASSY.	762.00	27866-LH	27866-LH	1	10110	1
2	SYNCHRO ASSY.	762.00	27866-RH	27866-RH	1	10110	1
3	SYNCHRO	88.00	78313	78313	2	10110	1
4	SWITCH ASSY.	35.00	90774	90774	2	10110	1
5	RELAY, 24VDC	9.75	71802	KRP14D	6	77342	2
6	RELAY, 24VDC	6.05	71808	T163-6C	2	70309	1
7	LAMP	5.00	71402	327	4	24446	Box of 10
8	FUSE HOLDER	1.00	71249	HKP	1	71400	1
9	FUSE, 3A, SB	1.25	71228	313003	1	75915	Box of 5

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3774-5/K482 NAME TRACKING CONVERTER

SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	INDICATOR UNIT	20.00	93507	93507	1	10110	1
2	INDICATOR UNIT	25.00	93510	93510	1	10110	1
3	METER ERROR AZ.	40.00	39124	39124	1	10110	1
4	METER ERROR EL.	40.00	39125	39125	1	10110	1
5	POT, DIAL FACE	43.00	77987	3600S-1-502	1	80295	1
6	SWITCH UNIT	45.00	93508	93508	1	10110	1
7	SWITCH UNIT	35.00	93509	93509	4	10110	1
8	SWITCH UNIT	40.00	93506	93506	2	10110	1
9	POWER SUPPLY 5820 255 2652	412.00	15631	15631	1	10110	1
10	DEMODULATOR	762.00	112053	112053	1	10110	1
11	PC DEMODULATOR	262.00	95254	95254	2	10110	1
12	RELAY	8.85	71808	T163-6C	6	70309	2
13	CARRIER LEVEL SENSING	1012.00	53159	53159	1	10110	1
14	ACQUIRE & LOSS	262.00	91469	91469	1	10110	1
15	AGC TEST & ADJUST	112.00	57889	57889	1	10110	1
16	CHAN. SEL. & NORM	262.00	94590	94590	1	10110	1

RECOMMENDED SPARES LIST

Reference Number 33S0050R

MODEL 3775A, 92678 NAME SCAN CODE GENERATOR

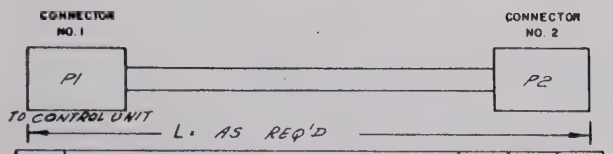
SHEET 1 OF 1

ITEM	NAME OR DESCRIPTION	UNIT PRICE	S-A PART NO.	MFR. PART NO.	QTY USED	FSCM	QTY SPARE
1	PC FLIP FLOP 5820 255 2680	232.00	90909	90909	1	10110	1
2	PC AZ. & EL. SCAN 5820 255 2681	262.00	91043	91043	1	10110	1
3	PC DEMOD. DRIVER 5820 255 2679	262.00	95226	95226	1	10110	1
4	PC SWEEP GEN. 5820 255 2657	287.00	90529	90529	1	10110	1
5	CAPACITOR 4500mfd 50V	10.00	70686	CG452U 50D1	1	37942	1
6	SWITCH TOGGLE	8.00	77280	7201	1	15605	1
7	SWITCH, PC MOUNT	10.00	79389	7101RPC	1	15605	1
8	HEAT SINK	1.85	77411	UD-T03	4	98979	2
9	TRANSISTOR	15.50	75961	2N3790	4	80211	2
10	DIODE	1.00	71124	1N1220	4	80211	2
11	FUSE HOLDER	1.00	71249	HKP	1	71400	1

SECTION 7
DIAGRAMS

Assembly drawings and schematic diagrams for the individual units of the K482 system are contained in the unit manuals. This section contains drawings of individual cables arranged in numerical order by cable part number. Drawing No. 112033 is the schematic diagram of the interface card file.

B19739



PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
A	115VAC				
B	115VAC COMMON				
C	GROUND				

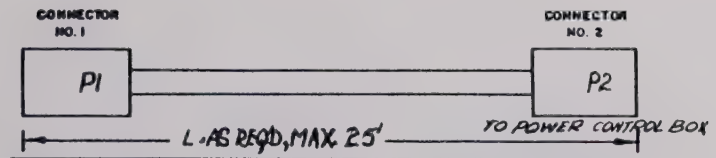
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC
1	2	A.C. POWER CORD, 3 CONDUCTOR, NO. 16 AWG	RE	5150			
1	1	CONNECTOR NO. 1	ABE	70957	MS3106A-18-8S		

LIST OF MATERIALS OR PARTS LIST

Cable No. B19739

7-3/7-4

B20267



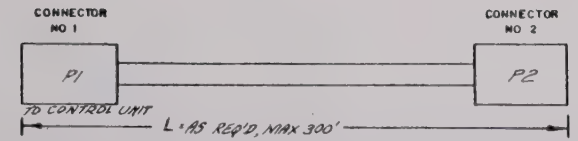
PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
A			A	16	4
B			B		
C			C		
G			G	16	4

QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG.	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL. SPEC.
	4	CABLE, 4 COND. #16 AWG	BX	76513	T-6661		
2	3	CLAMP, CABLE	ABE	70777	AN3057-10		
1	2	CONNECTOR NO. 2	ABE	70956	MS3106A-18-8P		
1	1	CONNECTOR NO. 1	ABE	70857	MS3106A-18-8S		

Cable No. B20267

7-5/7-6

B20353



PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
A			A	18	4
B			B		
C			C		
D			D		
E			E		
F			F		
G			G		
H			H		
J			J		
K			K		
L			L		
M			M		
N			N		
P			P		
R			R		
S			S		
T			T		
U			U		
V			V	18	4

* NOTE:
IF CABLE NOT FURNISHED,
CONNECTOR AS REQUIRED.

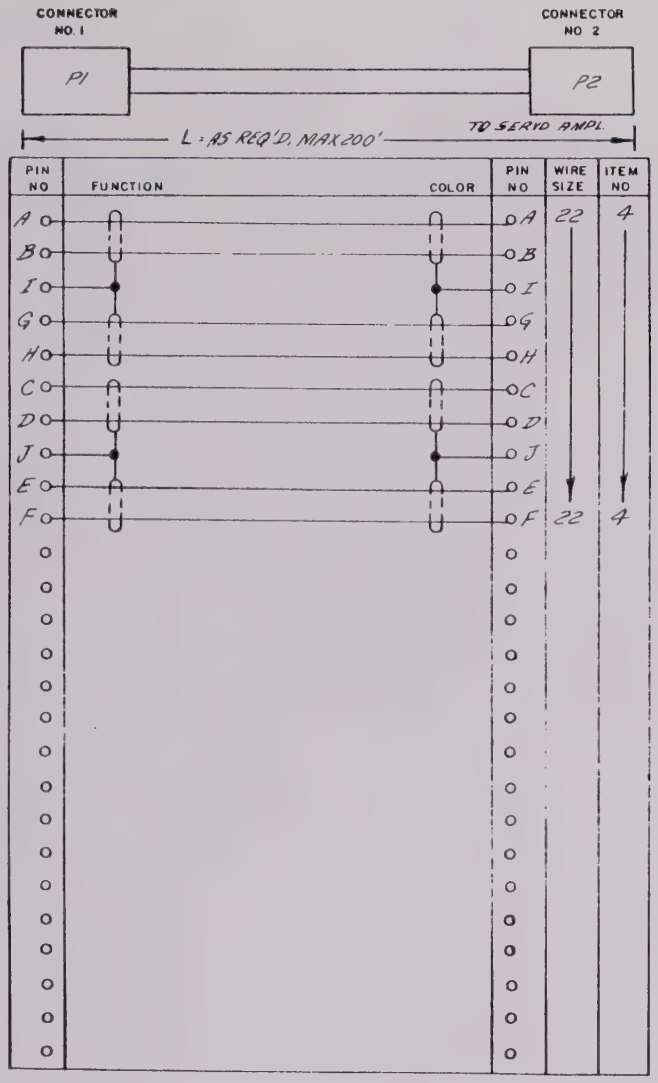
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC.
1	5	TUBING, BLACK	AN	PVC -105	PLASTIC	5/8"	
19	4	WIRE, INSULATED NO 18	BM	8522			
1	3	CABLE CLAMP	ABE	AN3057-12			
1	2	CONNECTOR NO 2		MS3106A-22-14S*			
1	1	CONNECTOR NO 1	ABE	MS3106A-22-14P			

LIST OF MATERIALS OR PARTS LIST

Cable No. B20353

8-7/7-8

B20465



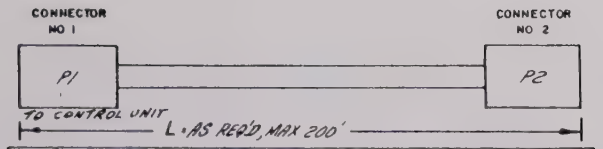
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE
1	5	TUBING, BLACK, PVC-105	AW	73235	PLASTIC	1/2"
4	4	WIRE, SH. PAIR NO. 22	BM	78454		
2	3	CABLE CLAMP	ABE	70777	AN3057-10	
1	2	CONNECTOR NO. 2	ABE	70955	MS3106A 28-15	
1	1	CONNECTOR NO. 1	ABE	70854	MS 3106A 28-1P	

LIST OF MATERIALS OR PARTS LIST

Cable B20465

OT-4/6-L

B20466



PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
A			A	18	4
B			B	18	4
C			C	18	4
D			D	18	4
E			E	16	5
F			F	18	4
G			G	16	5
H			H	18	4
I			I		
J			J		
K			K		
L			L		
M			M		
N			N		
P			P		
R			R		
S			S	18	4
T			T	16	5
U			U	18	4
V			V	18	4
W			W	18	4
X			X	18	4

QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC
1	6	TUBING, BLACK, PVC-105	AW	73237	PLASTIC	5/8"	
3	5	WIRE, INSULATED NO.16	BM	73341	8521		
19	4	WIRE INSULATED NO.18	BM	73356	8522		
2	3	CABLE CLAMP	ABE	70779	AN3057-16		
1	2	CONNECTOR NO.2	ABE	70991	MS3106A-28-11S		
1	1	CONNECTOR NO.1	ABE	70990	MS3106A-28-11P		

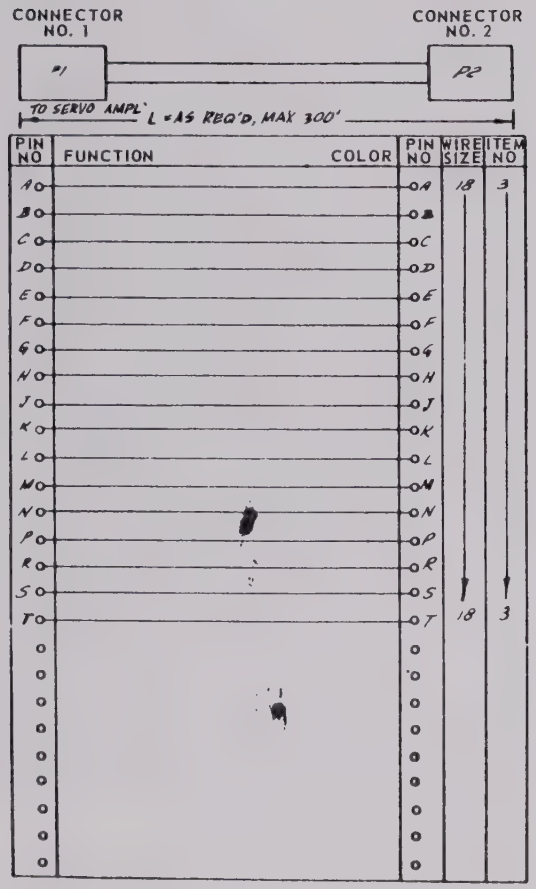
LIST OF MATERIALS OR PARTS LIST

Cable No. B20466

21-4/17-2

B21461

W 2.



*NOTE:
IF CABLE NOT FURNISHED, CONNECTOR AS REQUIRED.

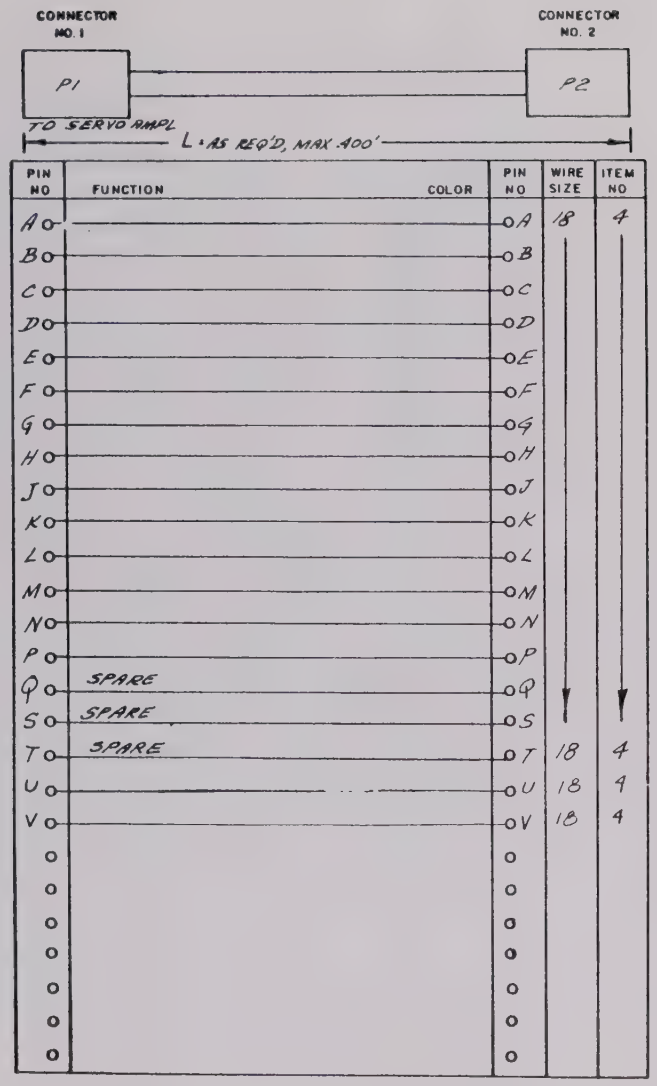
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC
1	5	CONNECTOR NO. 2		MS3106A-20-29P*			
	4	TUBING, BLACK	AW	PVC-105	PLASTIC	3/4"	
	3	WIRE NO. 18 STD	BM	8522			
1	2	CABLE CLAMP	ABE	AN3057-12			
1	1	CONNECTOR NO. 1	ABE	MS3106A-20-29S			

LIST OF MATERIALS OR PARTS LIST

Cable No. B21461

7-13/7-14

B21463A

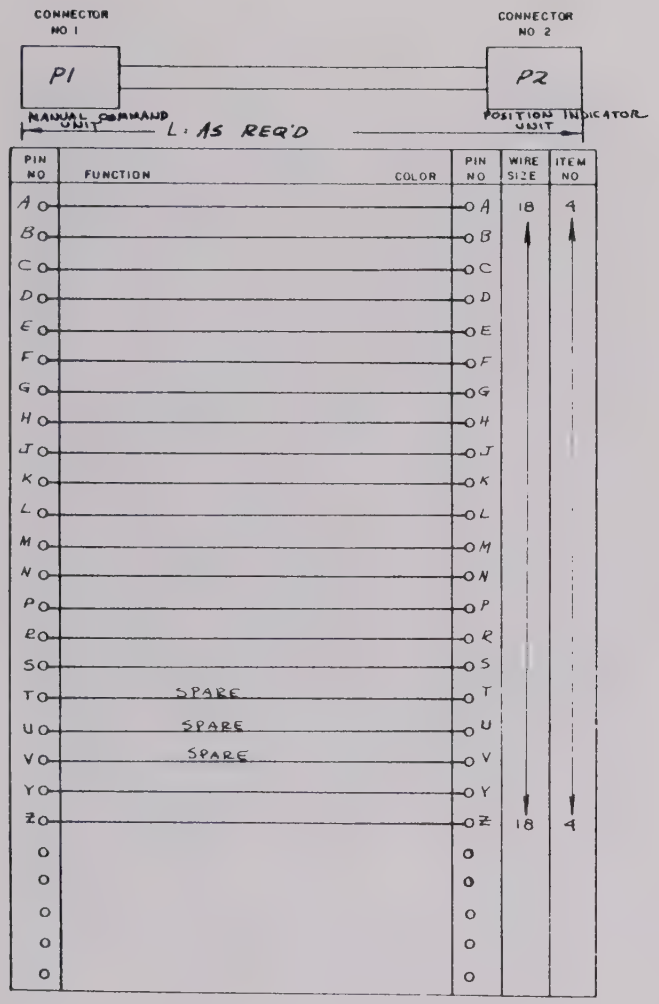


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE
	5	TUBING, BLACK, PVC-105	AW	73235	PLASTIC	1/2"
17	4	WIRE INSULATED	BM	73356		
2	3	CABLE CLAMP	ABE	70779	AN3057-16	
1	2	CONNECTOR NO. 2	ABE	70988	MS 3106A 24-28S	
1	1	CONNECTOR NO. 1	ABE	70986	MS 3106 A 24-28P	

Cable B21463A

7-15/7-16

B29841

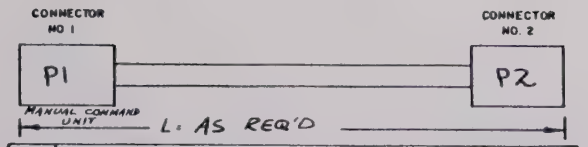


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE
	5	TUBING, BLACK, PVC-105	AW	73237	PLASTIC	5/8
21	4	WIRE, INSULATED	BM	73356	8522	
2	3	CABLE CLAMP	ABE	70779	AN3057-16	
1	2	CONNECTOR, CABLE, FEMALE	ABE	70988	MS3106A-24-28S	
1	1	CONNECTOR, CABLE, MALE	ABE	70986	MS3106A 24-28P	

Cable No. B29841

8T-L/7T-L

B29842



PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
A			A		
B			B		
C			C		
D			D		
E			E		
F			F		
G			G		
H			H		
J			J		
K			K		
L			L		
M			M		
N			N		
P			P		
Q			Q		
R			R		
S			S		
T			T		
U			U		
V			V		
W	SPARE		W		
X	SPARE		X		
Y	SPARE		Y		

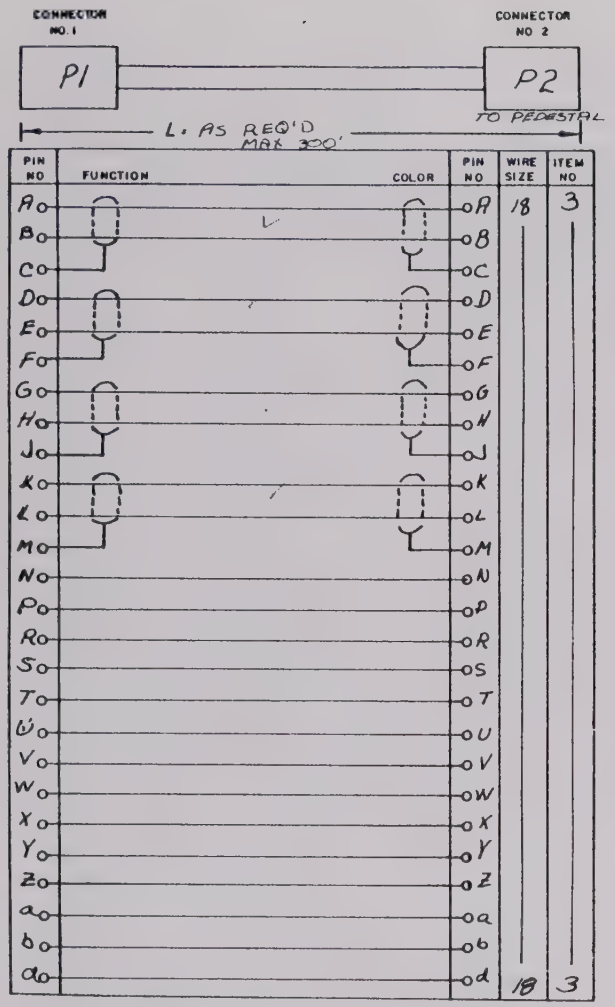
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG.	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL. SPEC.
	5	TUBING, BLACK	AW	PVC-105	PLASTIC		
23	4	WIRE INSULATED	BM	8522			
2	3	CABLE CLAMP	ABE	AN3057-16			
1	2	CONNECTOR, FEMALE	ABE	MS3106A-24-28S(G)			
1	1	CONNECTOR, MALE	ABE	MS3106A-24-28P(G)			

LIST OF MATERIALS OR PARTS LIST

Cable No. B29842

7-19/7-20

B37860A



W-4

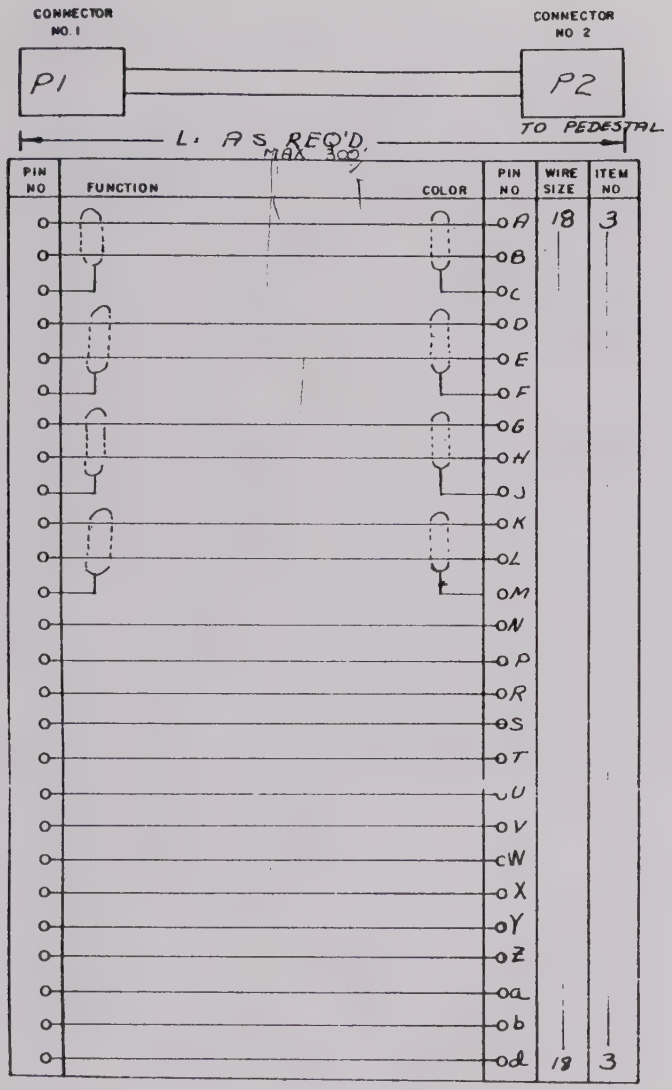
W-4

QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC.
1	4	CABLE CLAMP	ABE		AN3057-6		
	3	CABLE 19 WIRES #18 4 SH PAIRS #18	S.A.	70409	T.S. 3600-1A		
1	2	CONNECTOR #2	CE	78589	MS3108E-28-12P(Y)		
1	1	CONNECTOR #1	ABE	70996	MS3106A-28-12S(Y)		

Cable No. B37860A

7-21/7-22

B37861A



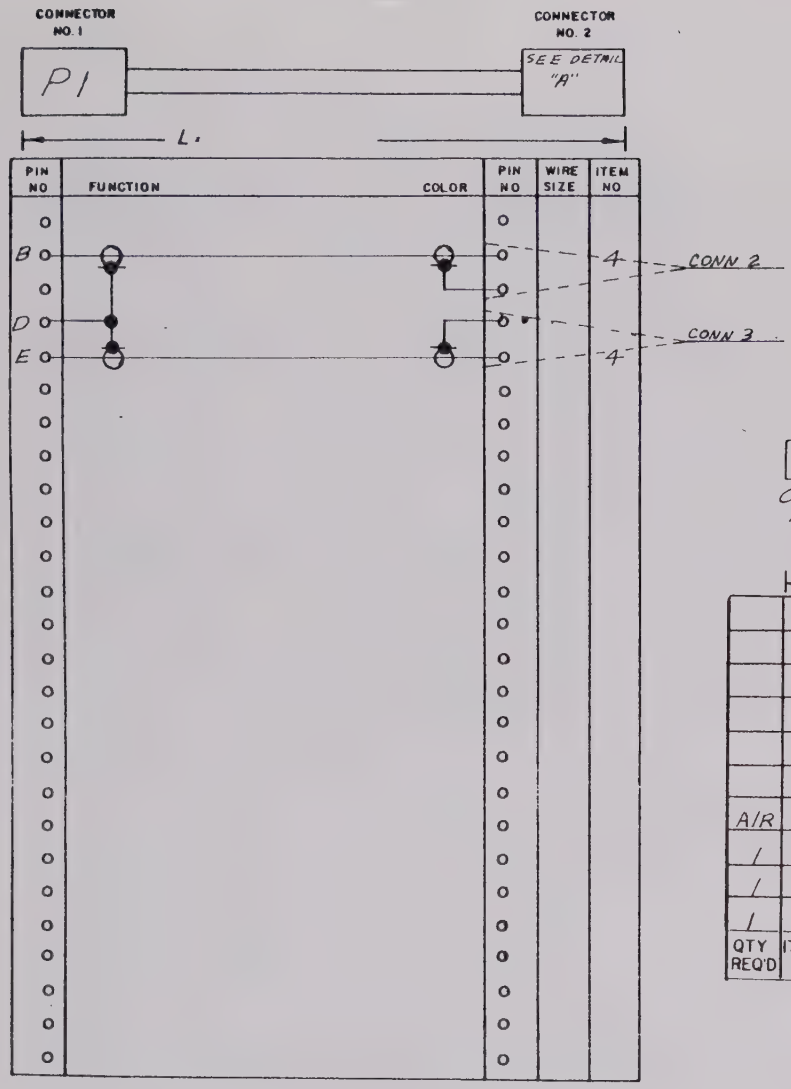
W-7

QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC
1	4	CABLE CLAMP	ABE	AN 3057-16			
	3	CABLE 14 WIRES #18 2 SH. PAIRS #18	S.A.	TS 3600-1A	70409		
1	2	CONNECTOR #2	CE	MS3108E28-12P(A)	78588		
1	1	CONNECTOR #1	ABE	MS3106A-28-12S(A)	70995		

Cable B37861A

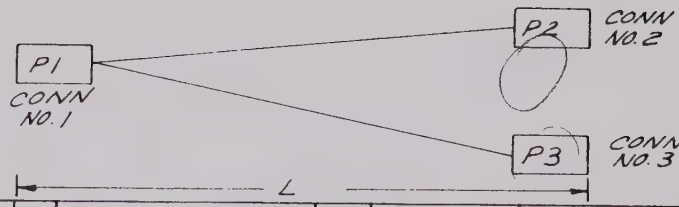
7-23/7-24

B37862A



W 6 W-6

"A"

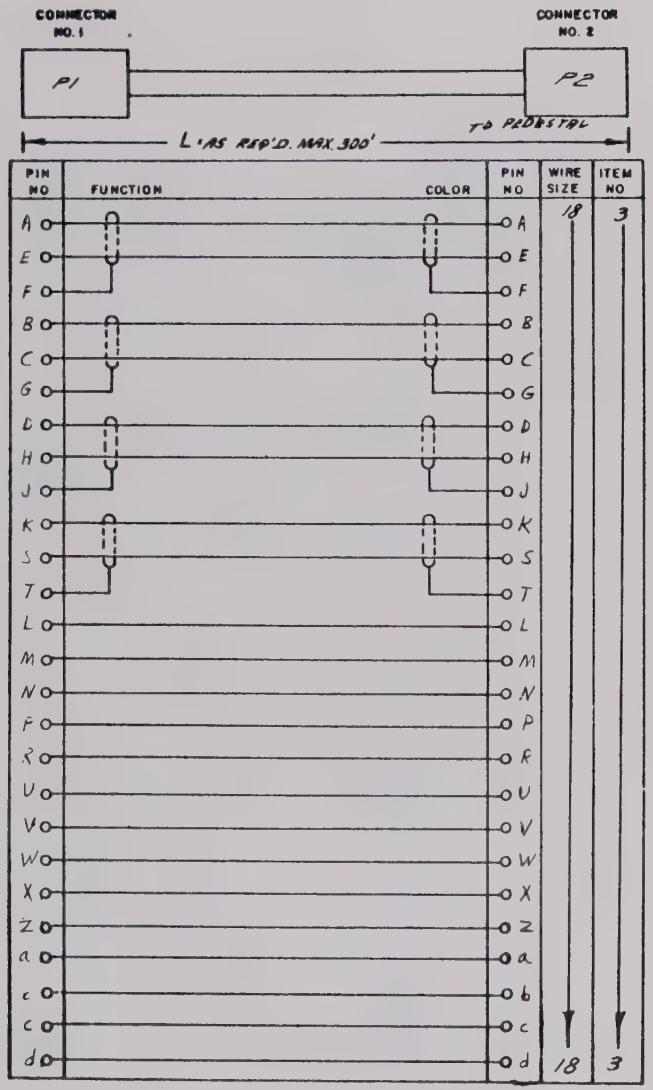


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC.
A/R	4	CABLE, COAX		70419		RG223	
1	3	CONNECTOR NO. 3	KI	74116		KI UG-88/U	
1	2	CONNECTOR NO 2	KI	74116		KI UG-88/U	
1	1	CONNECTOR NO. 1	ABE	70948		MS3106A-16S-1P	

Cable B37862A

7-25/7-26

B37863



SPARE PINS
e, f, g, h,
j, k, m, n,
p, r, s
NOT SHOWN

W - 5

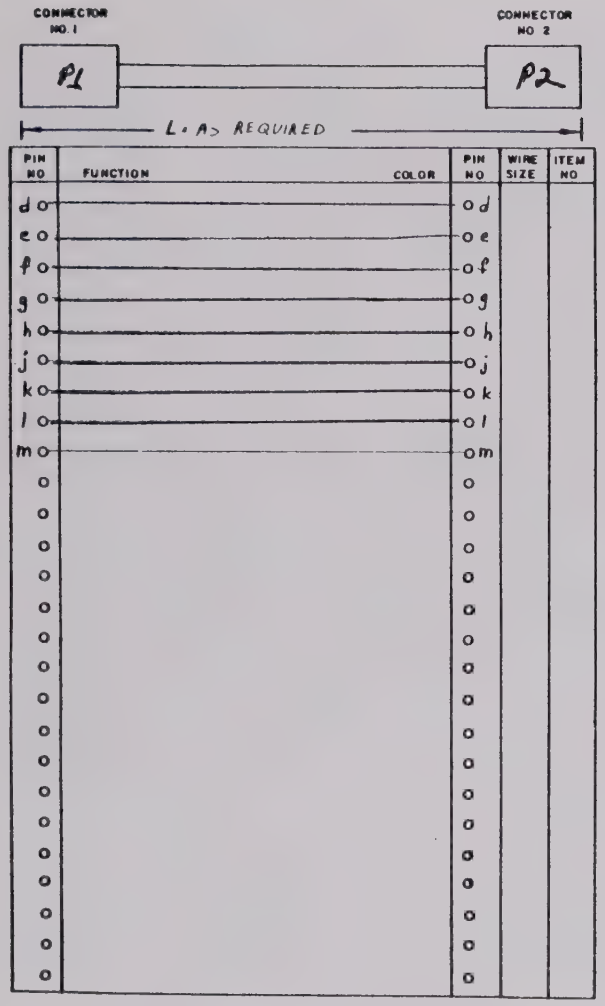
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL
1	4	CABLE CLAMP	ABE	AN 3057-16	
	3	CABLE 14 WIRES NO. 18 4 SH. PAIRS NO. 18	S.A.	T.S 3600-1A	
1	2	CONNECTOR NO2	CE	MS3108E28-21S	
1	1	CONNECTOR NO1	ABE	MS3106A28-21P	

LIST OF MATERIALS OR PARTS LIST

Cable B37863

7-27/7-28

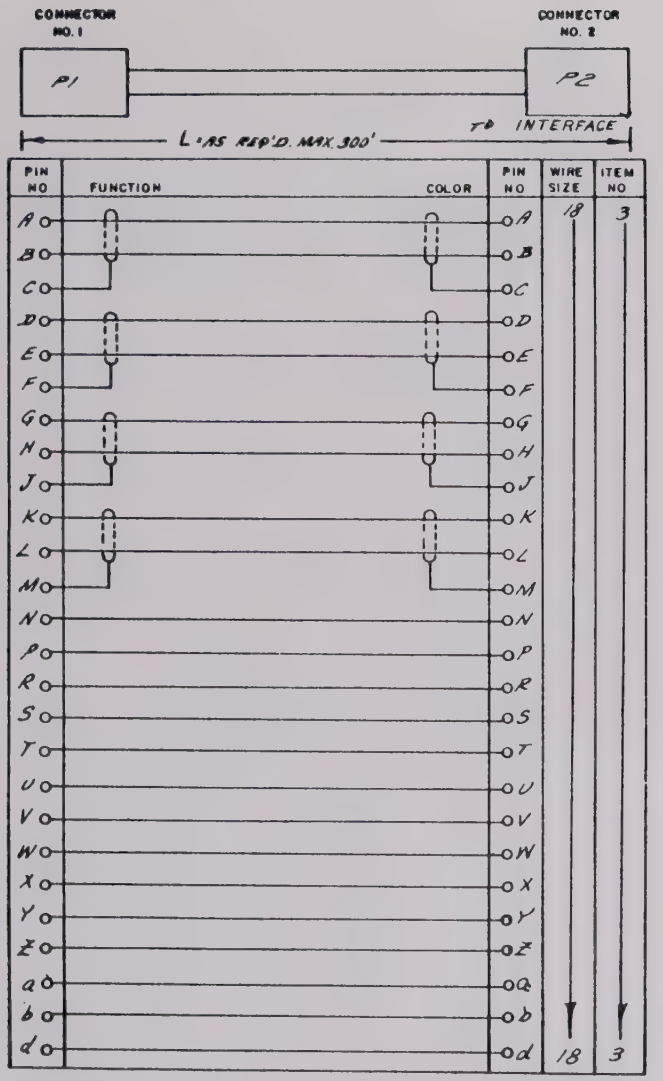
B37873



7-29/7-30

Cable No. B37873

B39455



1W9

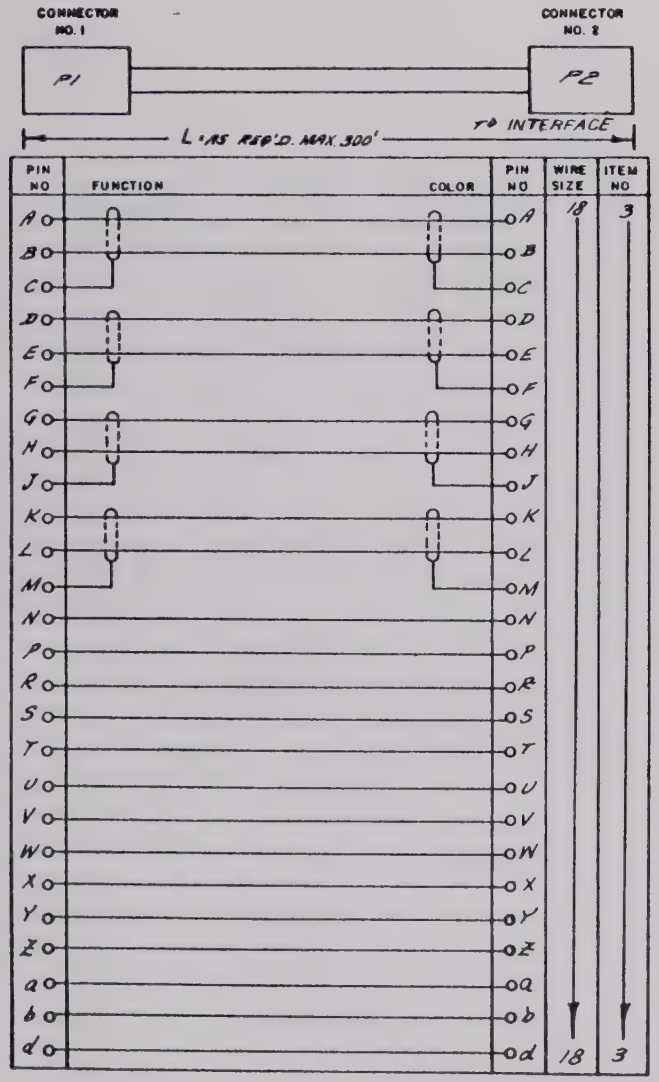
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC.
	5	TUBING, BLACK	AW	PIC 105	PLASTIC	3/4"	
2	4	CABLE CLAMP	ABE	AN 3057-16			
	3	19 WIRES NO 18 4 SH. PAIRS NO 18	BM				
1	2	CONNECTOR NO2	CE	MS 3106A28-12P(W)			
1	1	CONNECTOR NO1	ABE	MS3106A-28-12S(X)			

LIST OF MATERIALS OR PARTS LIST

Cable B39455

7-31/7-32

B39456



1W10

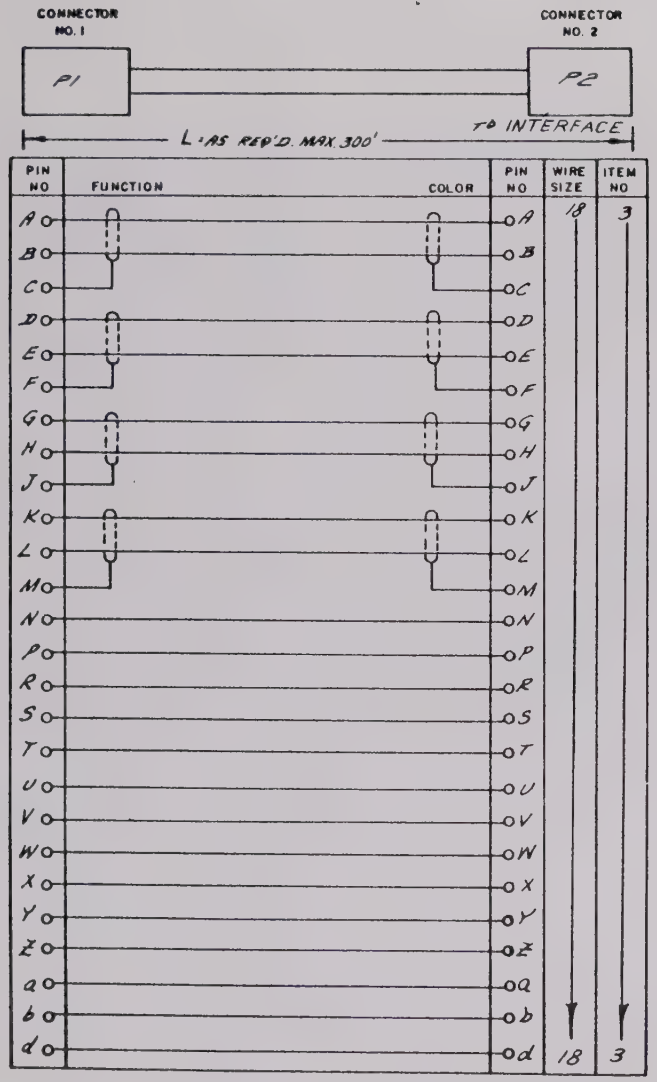
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL. SPEC.
	5	TUBING BLACK	AW	PIC-105 3/4	PLASTIC	3/4"	
2	4	CABLE CLAMP	ABE	AN 3057-16			
	3	14 WIRES NO. 18 4 S.H. PAIRS NO. 18	BM				
1	2	CONNECTOR NO2	CE	MS3106A28-12P(X)			
1	1	CONNECTOR NO1	ABE	MS3116A-28-12S(X)			

LIST OF MATERIALS OR PARTS LIST

Cable B39456

7-33/7-34

B39457



1W11 & 1W23

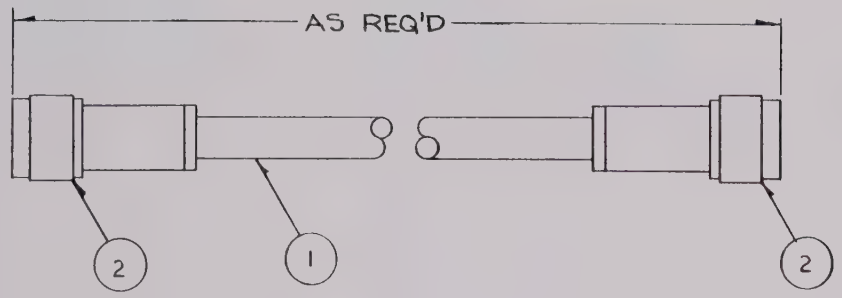
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL. SPEC.
	5	TUBING, BLACK	AW	PVC-105 3/4	PLASTIC	3/4"	
2	4	CABLE CLAMP	ABE	AN 3057-16			
	3	18 WIRES NO. 18 4 SH. PAIRS NO. 18	BM				
1	2	CONNECTOR NO2	CE	MS3106A 28-12P			
1	1	CONNECTOR NO1	ABE	MS3106A-28-12S			

LIST OF MATERIALS OR PARTS LIST

Cable B39457

7-35/7-36

B55940



QTY REQD	ITEM NO.	IDENTIFYING OR PART NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	STOCK SIZE	MATL SPEC	CODE IDENT
2	2	75318	CONNECTOR	UG21C/U			02660
1	1	70418	RF CABLE	RG214/U			70331

Cable No. B55940

7-37/7-38

B56930

PIN NO	FUNCTION	COLOR	PIN NO	WIRE SIZE	ITEM NO
o	AC HOT	BLACK	o	16	1
o	AC COMMON	WHITE	o		
o	GROUND	GREEN	o		
o			o		
o			o		
o			o		
o			o		
o			o		
o			o		
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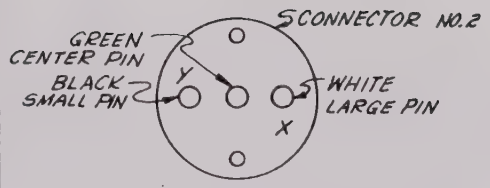
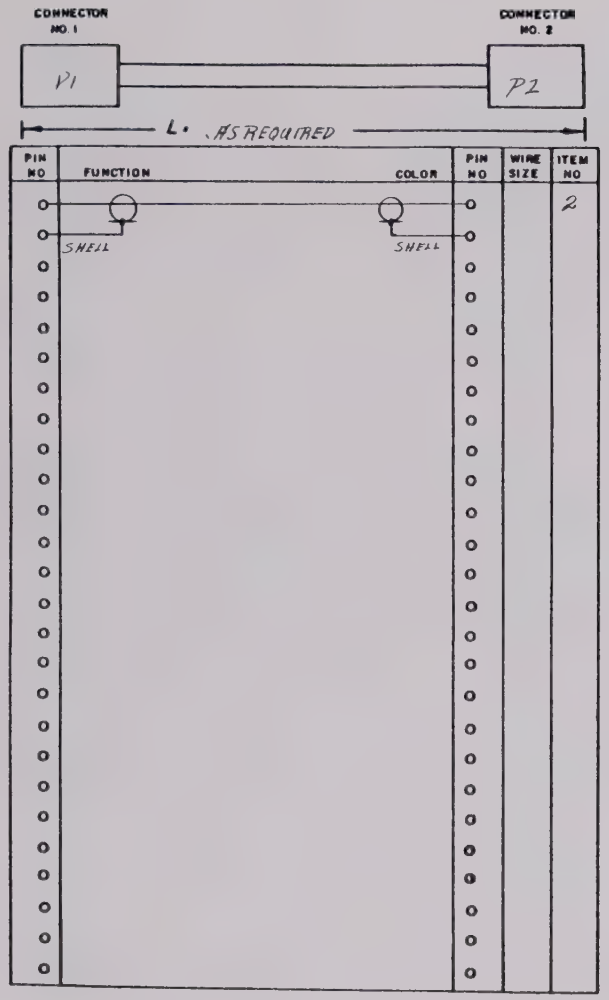


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO
1	2	CONNECTOR		71014
1	1	POWER CORD, K5150		71070

Cable No. B56930

7-39/7-40

B63392

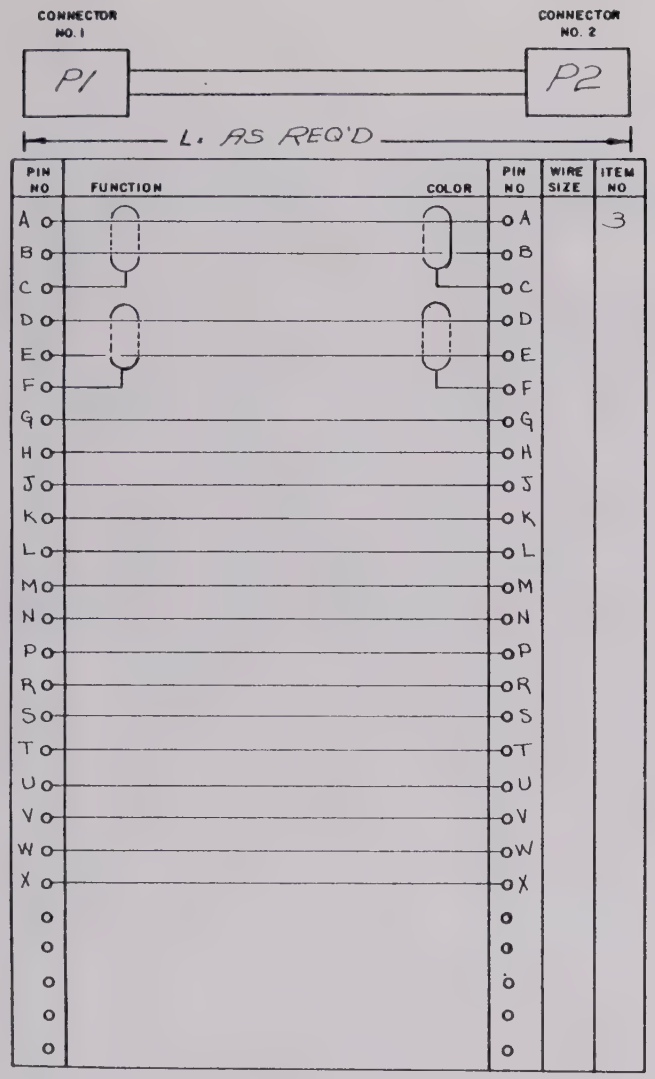


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO
	2	CABLE, COAXIAL	CW	RG223/U
2	1	CONNECTOR NO 1 & 2	ABE	31-326

Cable No. B63392

7-41/7-42

B94609

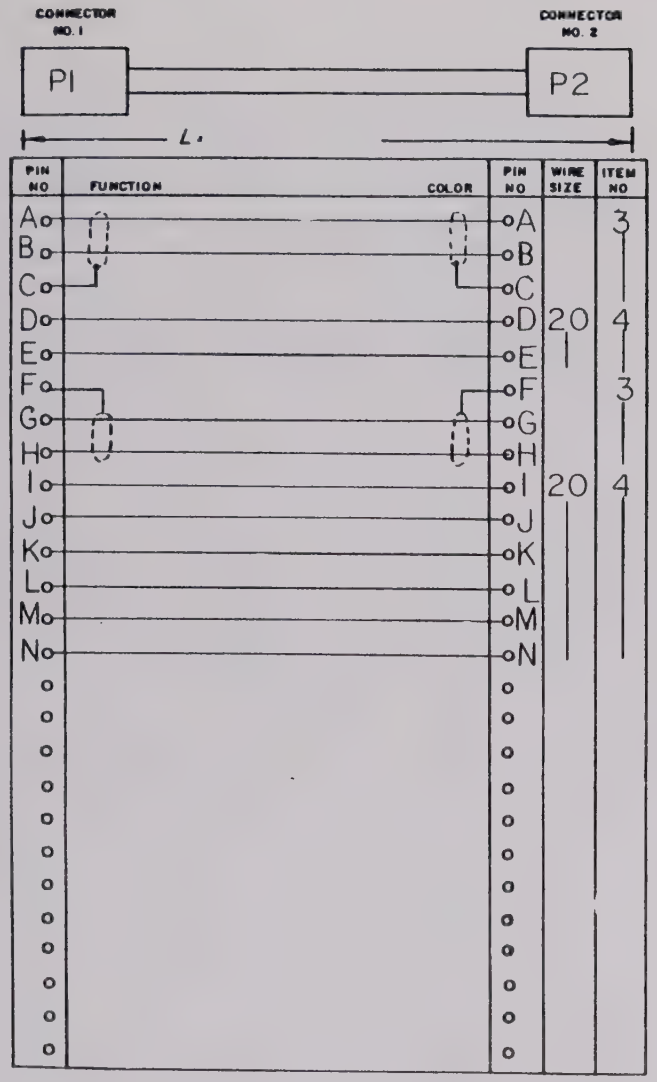


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG.	IDENTIFYING OR PART NO	MATERIAL
A/R	3	CABLE	SNC	79782	
1	2	CONNECTOR	BDW	79781	BT06W-20-27S
1	1	CONNECTOR	BDW	79780	BT06W-20-27P

Cable No. B94609

7-43/7-44

B94610

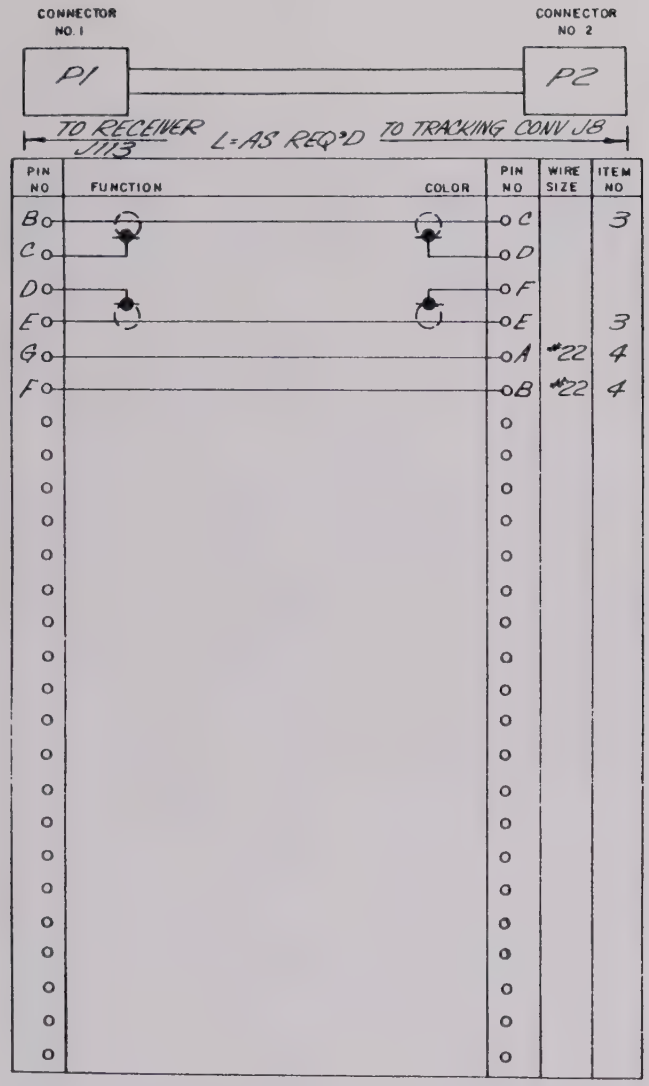


QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG.	IDENTIFYING OR PART NO
	5	TUBING, BLACK, VNL	MMM	73235
8	4	WIRE INS NO. 20	BM	73374
2	3	WIRE SH NO. 22	BX	78453
1	2	MS3106A-20-27S	ABE	70975
1	1	MS3106A-20-27P	ABE	70973

Cable No. B94610

94-7/45/7-46

B98751



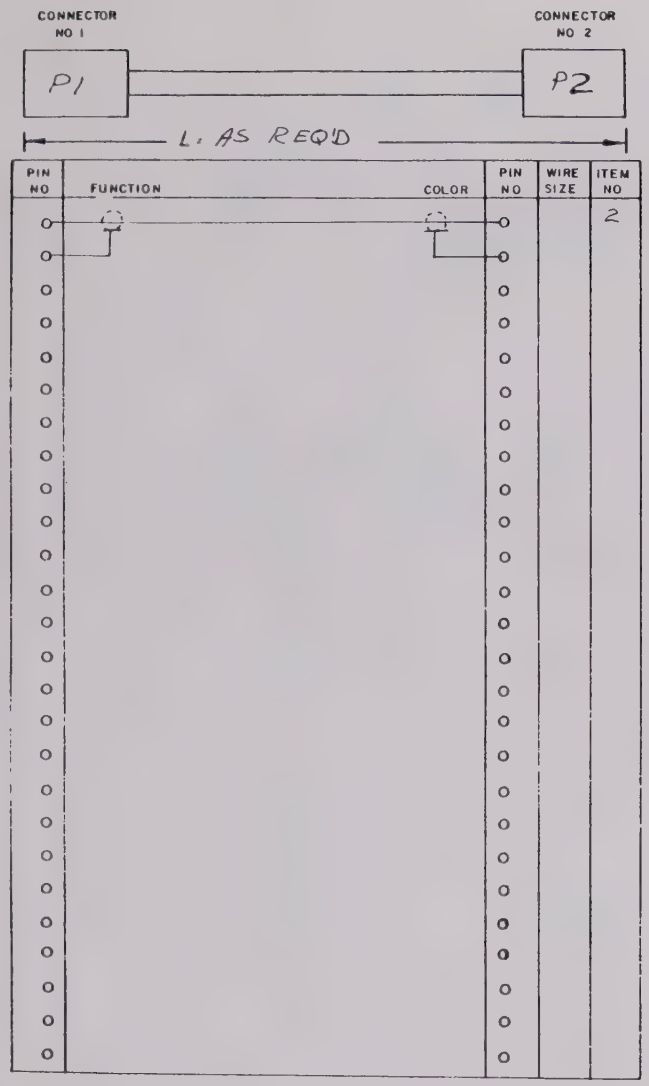
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE	MATL SPEC
2	4	#22 WIRE, STRANDED					
2	3	#22 SHIELDED WIRE					
1	2	CONNECTOR NO. 2	ABE	70947	3106A-MS-6S		
1	1	CONNECTOR NO. 1	ABE	70948	3106A-16-1P		

LIST OF MATERIALS OR PARTS LIST

Cable No. B98751

7-47/7-48

B98759



W 2 & W 3

Pow. Cord Co.

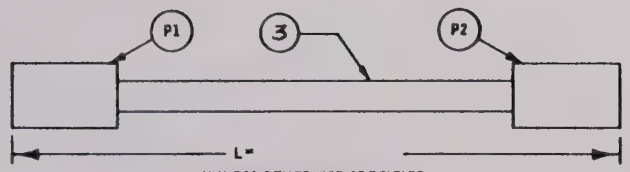
QTY REQ'D	ITEM NO	NOMENCLATURE OR DESCRIPTION	MFG	IDENTIFYING OR PART NO	MATERIAL	STOCK SIZE
1	2	SEMI-FLEX CORNAL CABLE	PDE		FXA-12SOM	
2	1	CONNECTOR #1, #2	PDE		FXA-12SONM	

LIST OF MATERIALS OR PARTS LIST

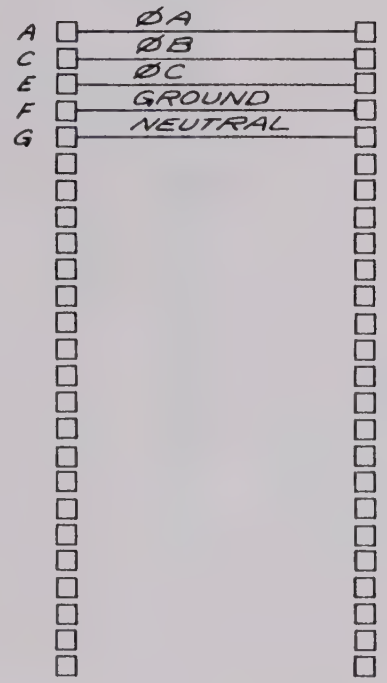
Cable B98759

7-49/7-50

B106861



UNLESS OTHERWISE SPECIFIED
REFER TO APPLICABLE
CABLING DIAGRAM FOR LENGTH



ITEM OR FIND NO	QTY REQD	S A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE
1	A/R	75172	CABLE	5-9 AWG
P2			(NOT PROVIDED)	
P1	1	78592	CONNECTOR	MS3108E-24-10S

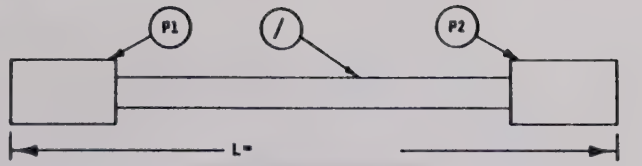
PARTS LIST

Cable B106861

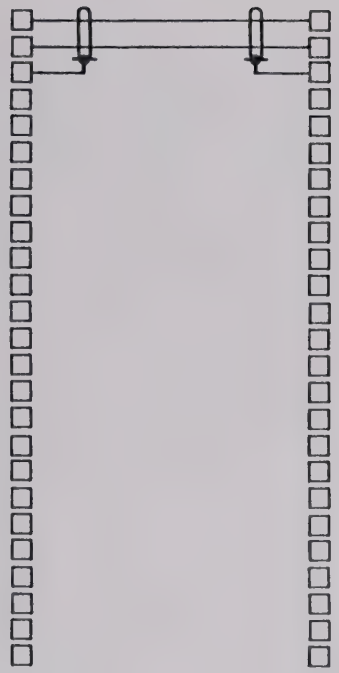
W1 - Power Input

7-51/7-52

B106862



UNLESS OTHERWISE SPECIFIED
REFER TO APPLICABLE
CABLING DIAGRAM FOR LENGTH



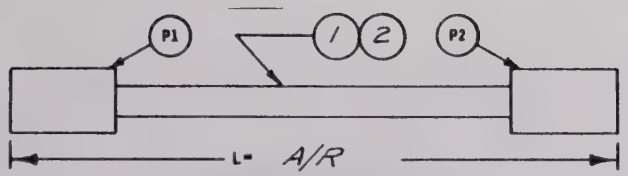
ITEM OR FIND NO.	QTY REQD	$ A STOCK NO	NOMENCLATURE OR DESCRIPTION	MAT. SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO	CODE IDENT
1	A/R		CABLE, TWINAX	TWC-124-2		14949
P2	1		CONNECTOR	BJ-79-2		14949
P1	1		CONNECTOR	PL-75		14349

PARTS LIST

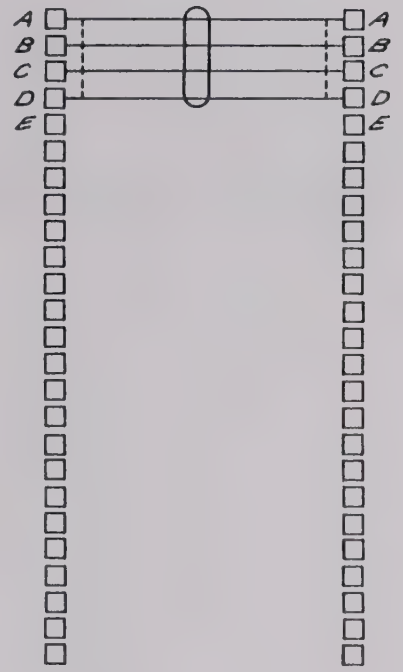
Cable B106862

7-53/7-54

B112040



UNLESS OTHERWISE SPECIFIED
REFER TO APPLICABLE
CABLING DIAGRAM FOR LENGTH

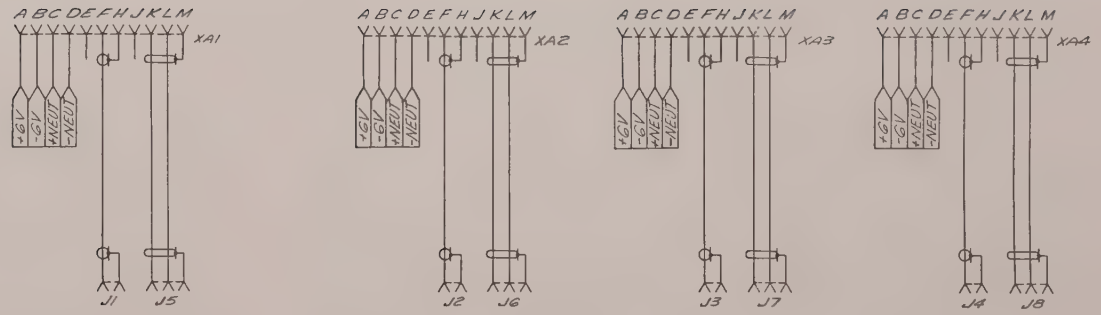


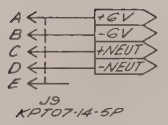
ITEM OR FIND NO	QTY REQD	S A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO	CODE IDENT
2	A/R	73234	TUBING, PVC			
1	A/R	73356	WIRE, STRANDED			
P2	1		CONNECTOR	KPT07E-14-5P		71468
P1	1		CONNECTOR	KPT06E-14-5S		71468

PARTS LIST

Cable B112040

7-55/7-56





NOTES:
1.) ALL PC CONNECTOR
22 PIN SINGLE READOUT.

Drawing No. 112033. Interface
Card File Schematic Diagram

C112033

7-57/7-58

CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

The basic chart below indicates the number of decibels (dB) corresponding to the listed ratios of voltage or power over the range of −20 to +20 dB. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in dB for each found separately, and the two results added. Example: To convert a power ratio of 2,000:1 to dB, express 2,000 as 2×10^3; the number of dB corresponding to a power ratio of 2 is very nearly 3, and the number of dB for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:1 is approximately 30 dB + 3 dB = 33 dB. In the lower righthand corner of the chart dB values for voltage and power ratios of integral powers of 10 are given.

Voltage Ratio	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*
1.000	**1.000**	**0**	**1.000**	**1.000**	**.447**	**.200**	**7.0**	**2.239**	**5.012**	**.200**	**.0398**	**14.0**	**5.012**	**25.12**
.989	.977	.1	1.012	1.023	.442	.195	7.1	2.265	5.129	.197	.0389	14.1	5.070	25.70
.977	.955	.2	1.023	1.047	.437	.191	7.2	2.291	5.248	.195	.0380	14.2	5.129	26.30
.966	.933	.3	1.035	1.072	.432	.186	7.3	2.317	5.370	.193	.0372	14.3	5.188	26.92
.955	.912	.4	1.047	1.096	.427	.182	7.4	2.344	5.495	.191	.0363	14.4	5.248	27.54
.944	.891	.5	1.059	1.122	.422	.178	7.5	2.371	5.623	.188	.0355	14.5	5.309	28.18
.933	.871	.6	1.072	1.148	.417	.174	7.6	2.399	5.754	.186	.0347	14.6	5.370	28.84
.923	.851	.7	1.084	1.175	.412	.170	7.7	2.427	5.888	.184	.0339	14.7	5.433	29.51
.912	.832	.8	1.096	1.202	.407	.166	7.8	2.455	6.026	.182	.0331	14.8	5.495	30.20
.902	.813	.9	1.109	1.230	.403	.162	7.9	2.483	6.166	.180	.0324	14.9	5.559	30.90
.891	**.794**	**1.0**	**1.122**	**1.259**	**.398**	**.159**	**8.0**	**2.512**	**6.310**	**.178**	**.0316**	**15.0**	**5.623**	**31.62**
.881	.776	1.1	1.135	1.288	.394	.155	8.1	2.541	6.457	.176	.0309	15.1	5.689	32.36
.871	.759	1.2	1.148	1.318	.389	.151	8.2	2.570	6.607	.174	.0302	15.2	5.754	33.11
.861	.741	1.3	1.161	1.349	.385	.148	8.3	2.600	6.761	.172	.0295	15.3	5.821	33.88
.851	.724	1.4	1.175	1.380	.380	.145	8.4	2.630	6.918	.170	.0288	15.4	5.888	34.67
.841	.708	1.5	1.189	1.413	.376	.141	8.5	2.661	7.079	.168	.0282	15.5	5.957	35.48
.832	.692	1.6	1.202	1.445	.372	.138	8.6	2.692	7.244	.166	.0275	15.6	6.026	36.31
.822	.676	1.7	1.216	1.479	.367	.135	8.7	2.723	7.413	.164	.0269	15.7	6.095	37.15
.813	.661	1.8	1.230	1.514	.363	.132	8.8	2.754	7.586	.162	.0263	15.8	6.166	38.02
.804	.646	1.9	1.245	1.549	.359	.129	8.9	2.786	7.762	.160	.0257	15.9	6.237	38.90
.794	**.631**	**2.0**	**1.259**	**1.585**	**.355**	**.126**	**9.0**	**2.818**	**7.943**	**.159**	**.0251**	**16.0**	**6.310**	**39.81**
.785	.617	2.1	1.274	1.622	.351	.123	9.1	2.851	8.128	.157	.0246	16.1	6.383	40.74
.776	.603	2.2	1.288	1.660	.347	.120	9.2	2.884	8.318	.155	.0240	16.2	6.457	41.69
.767	.589	2.3	1.303	1.698	.343	.118	9.3	2.917	8.511	.153	.0234	16.3	6.531	42.66
.759	.575	2.4	1.318	1.738	.339	.115	9.4	2.951	8.710	.151	.0229	16.4	6.607	43.65
.750	.562	2.5	1.334	1.778	.335	.112	9.5	2.985	8.913	.150	.0224	16.5	6.683	44.67
.741	.550	2.6	1.349	1.820	.331	.110	9.6	3.020	9.120	.148	.0219	16.6	6.761	45.71
.733	.537	2.7	1.365	1.862	.327	.107	9.7	3.055	9.333	.146	.0214	16.7	6.839	46.77
.724	.525	2.8	1.380	1.905	.324	.105	9.8	3.090	9.550	.145	.0209	16.8	6.918	47.86
.716	.513	2.9	1.396	1.950	.320	.102	9.9	3.126	9.772	.143	.0204	16.9	6.998	48.98
.708	**.501**	**3.0**	**1.413**	**1.995**	**.316**	**.100**	**10.0**	**3.162**	**10.000**	**.141**	**.0200**	**17.0**	**7.079**	**50.12**
.700	.490	3.1	1.429	2.042	.313	.0977	10.1	3.199	10.23	.140	.0195	17.1	7.161	51.29
.692	.479	3.2	1.445	2.089	.309	.0955	10.2	3.236	10.47	.138	.0191	17.2	7.244	52.48
.684	.468	3.3	1.462	2.138	.306	.0933	10.3	3.273	10.72	.137	.0186	17.3	7.328	53.70
.676	.457	3.4	1.479	2.188	.302	.0912	10.4	3.311	10.96	.135	.0182	17.4	7.413	54.95
.668	.447	3.5	1.496	2.239	.299	.0891	10.5	3.350	11.22	.133	.0178	17.5	7.499	56.23
.661	.437	3.6	1.514	2.291	.295	.0871	10.6	3.388	11.48	.132	.0174	17.6	7.586	57.54
.653	.427	3.7	1.531	2.344	.292	.0851	10.7	3.428	11.75	.130	.0170	17.7	7.674	58.88
.646	.417	3.8	1.549	2.399	.288	.0832	10.8	3.467	12.02	.129	.0166	17.8	7.762	60.26
.638	.407	3.9	1.567	2.455	.285	.0813	10.9	3.508	12.30	.127	.0162	17.9	7.852	61.66
.631	**.398**	**4.0**	**1.585**	**2.512**	**.282**	**.0794**	**11.0**	**3.548**	**12.59**	**.126**	**.0159**	**18.0**	**7.943**	**63.10**
.624	.389	4.1	1.603	2.570	.279	.0776	11.1	3.589	12.88	.125	.0155	18.1	8.035	64.57
.617	.380	4.2	1.622	2.630	.275	.0759	11.2	3.631	13.18	.123	.0151	18.2	8.128	66.07
.610	.372	4.3	1.641	2.692	.272	.0741	11.3	3.673	13.49	.122	.0148	18.3	8.222	67.61
.603	.363	4.4	1.660	2.754	.269	.0724	11.4	3.715	13.80	.120	.0145	18.4	8.318	69.18
.596	.355	4.5	1.679	2.818	.266	.0708	11.5	3.758	14.13	.119	.0141	18.5	8.414	70.79
.589	.347	4.6	1.698	2.884	.263	.0692	11.6	3.802	14.45	.118	.0138	18.6	8.511	72.44
.582	.339	4.7	1.718	2.951	.260	.0676	11.7	3.846	14.79	.116	.0135	18.7	8.610	74.13
.575	.331	4.8	1.738	3.020	.257	.0661	11.8	3.890	15.14	.115	.0132	18.8	8.710	75.86
.569	.324	4.9	1.758	3.090	.254	.0646	11.9	3.936	15.49	.114	.0129	18.9	8.811	77.62
.562	**.316**	**5.0**	**1.778**	**3.162**	**.251**	**.0631**	**12.0**	**3.981**	**15.85**	**.112**	**.0126**	**19.0**	**8.913**	**79.43**
.556	.309	5.1	1.799	3.236	.248	.0617	12.1	4.027	16.22	.111	.0123	19.1	9.016	81.28
.550	.302	5.2	1.820	3.311	.246	.0603	12.2	4.074	16.60	.110	.0120	19.2	9.120	83.18
.543	.295	5.3	1.841	3.388	.243	.0589	12.3	4.121	16.98	.108	.0118	19.3	9.226	85.11
.537	.288	5.4	1.862	3.467	.240	.0575	12.4	4.169	17.38	.107	.0115	19.4	9.333	87.10
.531	.282	5.5	1.884	3.548	.237	.0562	12.5	4.217	17.78	.106	.0112	19.5	9.441	89.13
.525	.275	5.6	1.905	3.631	.234	.0550	12.6	4.266	18.20	.105	.0110	19.6	9.550	91.20
.519	.269	5.7	1.928	3.715	.232	.0537	12.7	4.315	18.62	.104	.0107	19.7	9.661	93.33
.513	.263	5.8	1.950	3.802	.229	.0525	12.8	4.365	19.05	.102	.0105	19.8	9.772	95.50
.507	.257	5.9	1.972	3.890	.227	.0513	12.9	4.416	19.50	.101	.0102	19.9	9.886	97.72
.501	**.251**	**6.0**	**1.995**	**3.981**	**.224**	**.0501**	**13.0**	**4.467**	**19.95**	**.100**	**.0100**	**20.0**	**10.000**	**100.00**
.496	.246	6.1	2.018	4.074	.221	.0490	13.1	4.519	20.42					
.490	.240	6.2	2.042	4.169	.219	.0479	13.2	4.571	20.89	10^{-2}	10^{-3}	30		10^{3}
.484	.234	6.3	2.065	4.266	.216	.0468	13.3	4.624	21.38		10^{-4}	40	10^{2}	10^{4}
.479	.229	6.4	2.089	4.365	.214	.0457	13.4	4.677	21.88					
											10^{-5}	50		10^{5}
.473	.224	6.5	2.113	4.467	.211	.0447	13.5	4.732	22.39	10^{-3}	10^{-6}	60	10^{3}	10^{6}
.468	.219	6.6	2.138	4.571	.209	.0437	13.6	4.786	22.91		10^{-7}	70		10^{7}
.462	.214	6.7	2.163	4.677	.207	.0427	13.7	4.842	23.44	10^{-4}	10^{-8}	80	10^{4}	10^{8}
.457	.209	6.8	2.188	4.786	.204	.0417	13.8	4.898	23.99		10^{-9}	90		10^{9}
.452	.204	6.9	2.213	4.898	.202	.0407	13.9	4.955	24.55					
										10^{-5}	10^{-10}	100	10^{5}	10^{10}
											10^{-11}	110		10^{11}
										10^{-6}	10^{-12}	120	10^{6}	10^{12}

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TECHNICAL DISCUSSION
SCAN-CODED SINGLE CHANNEL MONOPULSE AUTOMATIC TRACKING SYSTEMS

By
P. M. Pifer
Manager
Telemetry and Control Systems

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TECHNICAL DISCUSSION
SCAN-CODED SINGLE CHANNEL MONOPULSE

INTRODUCTION

Requirements of telemetry antenna tracking systems summarily include the ability to automatically point the antenna at the data source with a medium to high degree of accuracy, the provision for low noise RF signal and data processing, an immunity to the cyclic amplitude variations which are generally present on the received RF signal, and the proper servo error signal processing to avoid a degradation of the data present on the incoming RF signal. Additionally important as a very practical consideration is the requirement that the system also provide simplicity of operation and reliability.

Single channel receiving systems used for automatic servo positioning of a tracking antenna typically employ a form of conical scanning or sequential antenna beam lobing. Both forms are found to be degraded or rendered useless by target scintillation - vehicle spin, transmitter interference modulation or propagation conditions. By contrast, simultaneous lobing monopulse systems can derive angular tracking information simultaneously as a ratio of target signal received on two or more different antenna patterns. Thus, variations of target signal amplitude and phase from moment to moment, except for perturbations through the multi-channel receiver, do not degrade the determination of angle of arrival of target signal in the monopulse system.

Monopulse and conical scanning techniques both have been utilized with varying degrees of success in the past, and the characteristics of such systems are well documented. Conical scanning generally suffers the disadvantages of crossover loss, high susceptibility to cyclic amplitude modulation, and mechanical scan rates limited at 10 to 60 cycles per second.

Monopulse systems require excellent receiver phase and AGC stability, and generally require that manual phase alignment be made in the receiving subsystem when the operating frequency is changed. Since the basic monopulse

is a two- or three-channel system, continuously rotating pedestal axes either require multi-channel rotary joints or dictate a location of the receiver above the axis of rotation. In systems featuring frequency or polarization diversity, the RF hardware problems become additionally compounded.

The Scan-Coded single-channel monopulse system derives the sum and difference signals from a conventional phase or amplitude monopulse antenna but then combines them into a single composite RF signal in a coded time shared manner. This resultant RF signal can be processed with a conventional single channel receiver. The servo error signals are derived with a synchronous amplitude detector.

A typical single frequency, single polarized system block diagram incorporating coding techniques is shown in Figure 1.

THEORY

The automatic tracking system of Figure 1 functions to derive azimuth and elevation dc error voltages proportional to the monopulse RF error signals. These dc error signals are then utilized to servo position the antenna automatically to its zero boresight direction, relative to the transmitting target.

Successful processing of the RF signals into a single channel form is accomplished by a single channel monopulse converter. Figure 2 shows a simplified block diagram to demonstrate the principle of operation of the conversion process.

The three monopulse RF CW signals for small angles off-boresight are given by:

$$E_{\Sigma} = B_1 E_m \sin \omega t \quad (1)$$

$$E_{(\Delta\phi)} \tilde{=} B_2 E_m \Delta\phi \sin \omega t \quad (2)$$

$$E_{(\Delta\theta)} \tilde{=} B_2 E_m \Delta\theta \sin \omega t \quad (3)$$

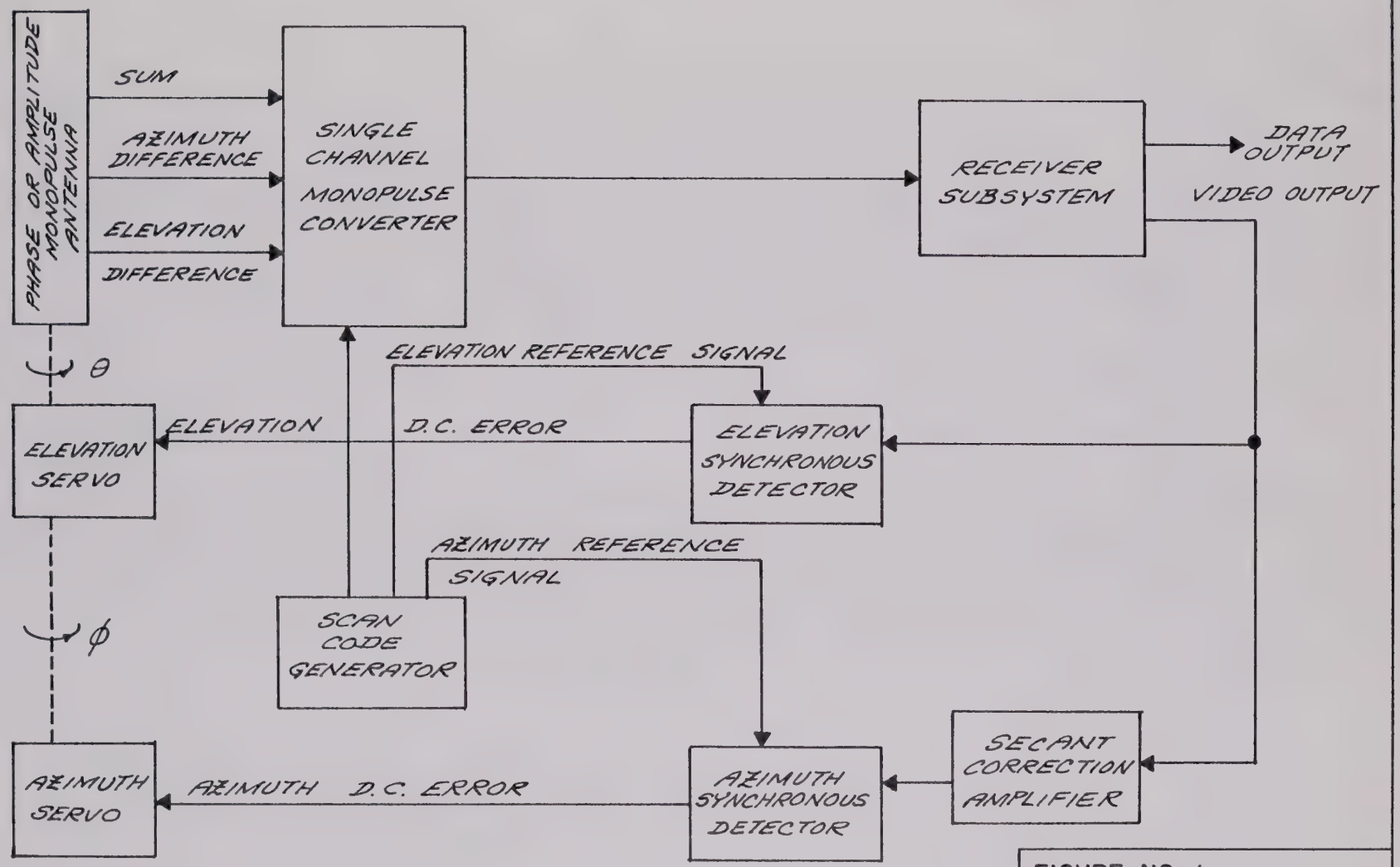

FIGURE NO. /

TITLE
TYPICAL SCAN CODED SINGLE CHANNEL MONOPULSE SYSTEM

REFERENCE

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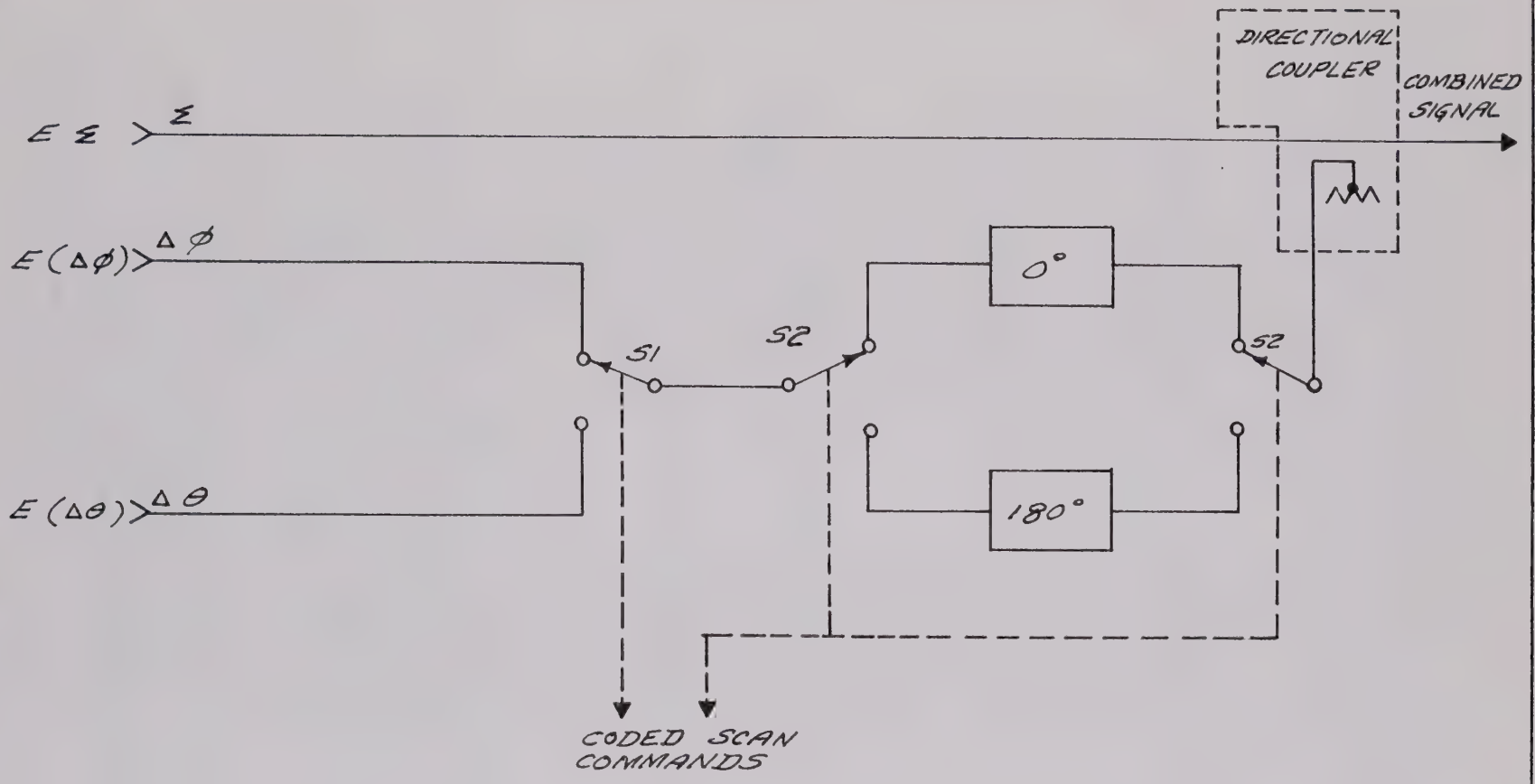

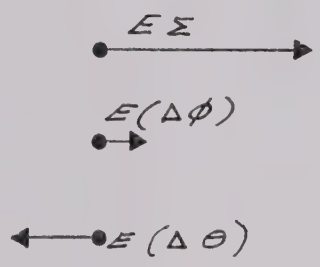

FIG. 2A - TYPICAL RF SIGNAL VECTORS

FIGURE NO. 2

TITLE SIMPLIFIED BLOCK DIAGRAM SINGLE CHANNEL MONOPULSE CONVERTER

Page

Where $\Delta\phi$ and $\Delta\theta$ are the angular deviations from boresight in the two orthogonal tracking coordinates and E_m is the RF voltage amplitude. Signal combining may be introduced on the RF sum signal by alternating addition of the sum signal and the error RF signals in phase and 180 degrees out of phase. Refer also to Figure 3.

1) S1 selects the azimuth error signal with S2 selecting 0 degree phase shift. $E_{(\Delta\phi)}$ is added in phase with E_Σ by a coupler to yield a total RF vector of $E_\Sigma + E_{(\Delta\phi)}$.

2) S2 switches to shift $E_{(\Delta\phi)}$ 180 degrees in phase. The combined signal then becomes

$$E_\Sigma - E_{(\Delta\phi)}.$$

3) S1 selects $E_{(\Delta\theta)}$ with S2 returned to provide 0° phase shift. $E_{(\Delta\theta)}$ is added in phase with E_Σ to form the voltage vector amplitude $E_\Sigma + E_{(\Delta\theta)}$.

4) S2 switches to introduce 180° of phase shift. The combined signal then becomes

$$E_\Sigma - E_{(\Delta\theta)}.$$

It can be seen from Figure 3A that the peak to peak amplitude of the combined RF signal during periods 1 and 2 is proportional to the magnitude of the angle off-boresight in ϕ, with the phase relationship of the amplitude modulation relative to S2 switch position determining the direction off-boresight. During periods 3 and 4 the amplitude modulation similarly is related to angle off-boresight in the θ coordinate.

After video detection in a conventional receiver, the modulation envelope is converted to dc voltages by synchronous detectors, gated by signals driving switches S1 and S2. The servo system then rotates the antenna until the dc error voltages are reduced to zero.

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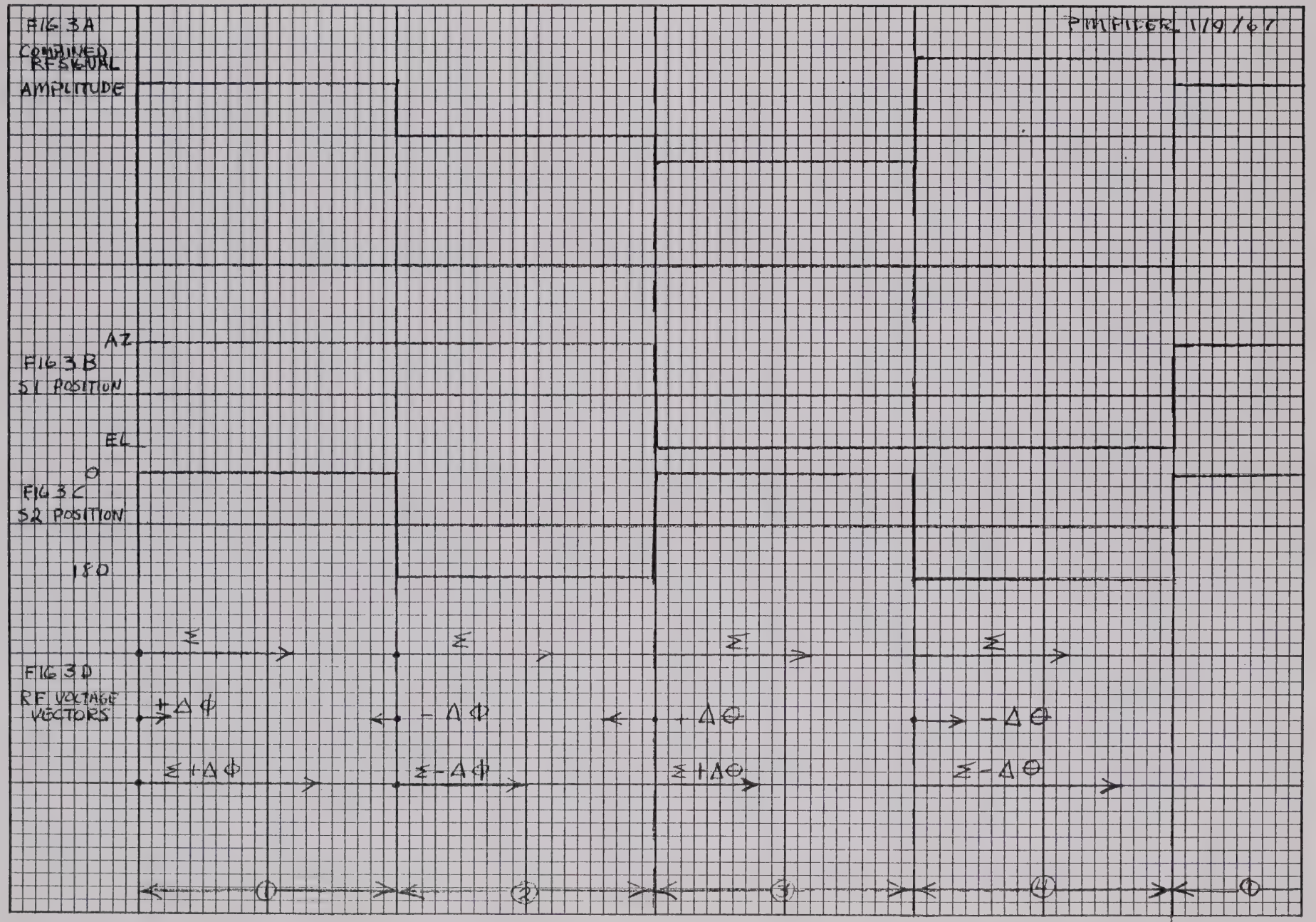

FIG. 5 - SINGLE CHANNEL MONOPULSE

ERROR CODING[1]

As previously mentioned, tracking systems which utilize cyclic RF amplitude modulation for single channel signal processing (e.g. conical scanning) are susceptable to amplitude modulation imposed on the received RF signal at or near the scan rate.

This "noise" modulation may be a result of the transmitted signal characteristic, as in the case of pulse amplitude modulated data signals, or it may be a result of the transmitter vehicle spin, scintillation, propeller modulation or cyclic multipath fades. The highest density of noise modulation is found below 50 cps, although background and propeller modulation effects may occur up to several hundred cps.

One of the most apparent solutions then is to utilize a scanning frequency which is above 50 cps and reduce the probability of interference. To further reduce the effects from interference, it is desirable to perform error modulation in a psuedo-random fashion, rather than in the cyclic sequence previously described, to result in an error signal which is "coded".

For example, refer to the four sequences required above for complete two-axis sampling.

A modulation sequence of steps 1, 2, 4, 3, 3, 1, 4, 2 would result in two complete samples of the azimuth and elevation error signals, but with the more complex waveshape as shown in Figure 4A. Coding may also be applied by randomly varying the time interval between samples or by a combination of both as shown in Figure 4B. The probability and severity of interference thus can be reduced by increasing the complexity of the error coding.

CONVERTER DESIGN CONSIDERATIONS

To meet the requirements for successful operation as part of the telemetry data processing system, the single channel converter must be carefully designed with

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[1] Patent applied for.

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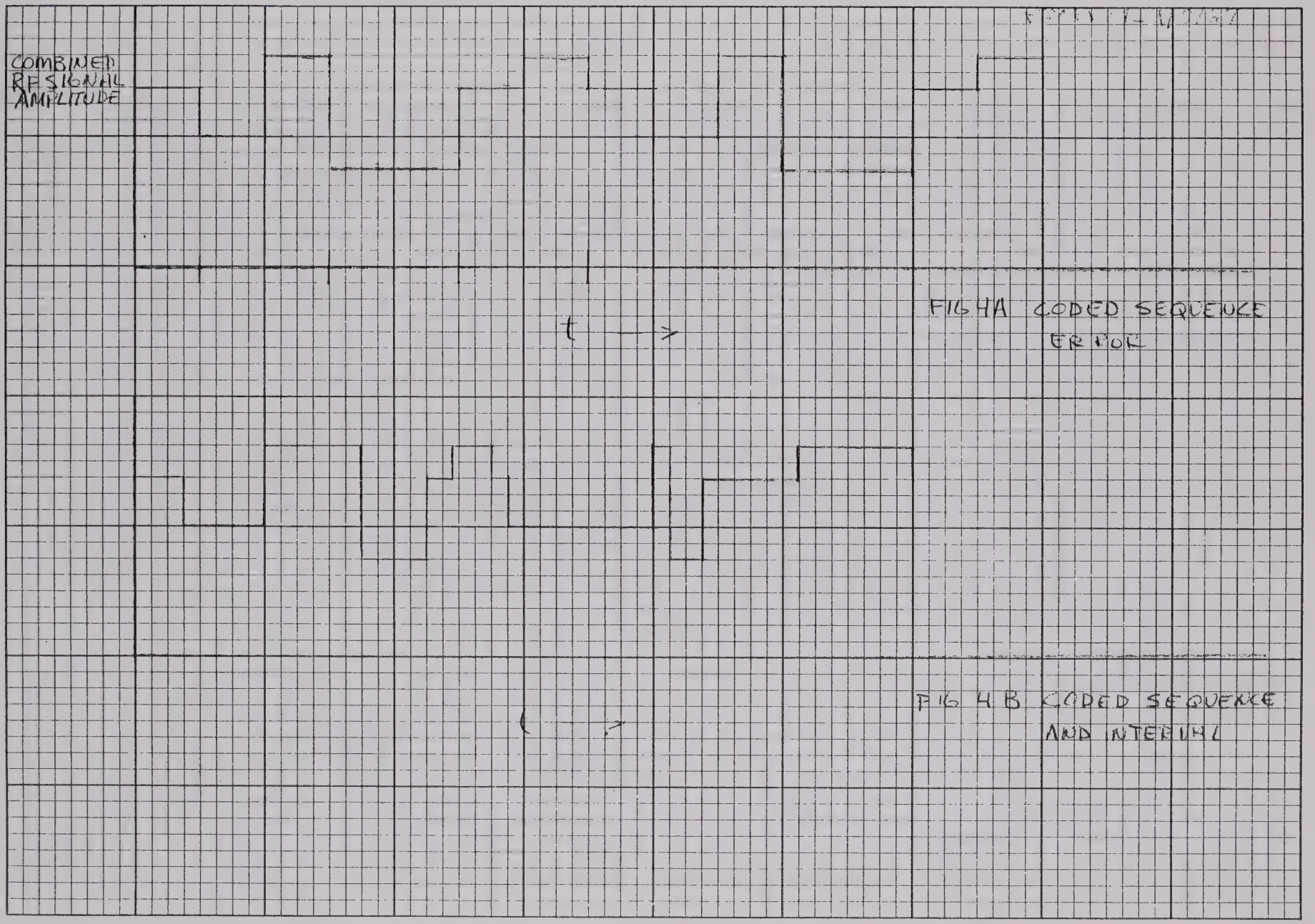

FIG 4A CODED SEQUENCE ERROR

FIG 4B CODED SEQUENCE AND INTERVAL

the following characteristics:

1) Sum channel insertion loss must be minimum, preferably 0.5 db to 1.0 db.

2) Phase shifting or switching must be accomplished in the error channels to avoid interruption of data. Additionally, the difference inputs should be isolated to avoid transients through the monopulse networks to the sum input.

3) The phase shift characteristics of the sum and error channels through the converter must be matched and controlled over the frequency range and temperature ranges required, to insure that proper summation as described in Figure 3 will occur. It should be noted, however, that the requirements for phase tracking are not extremely critical. The prime effect of imperfect phase tracking is to change the servo loop gain or the cosine of the phase shift angle, without the effects of crosstalk or boresight shift. On this basis it is desirable to maintain RF phase tracking to ±20° under all conditions of operation, which results in only a 6% change in servo loop gain.

4) To avoid the undesirable effects of crosstalk, error channel isolation must be maintained at 20 db or greater.

5) The insertion loss of the error channel is relatively non-critical, when compared to the sum channel insertion loss. The major effect of error channel insertion loss is to reduce the amount of modulation for a given angular error. However, it is desirable to maintain error channel insertion loss (before summing) to 2 or 3 db.

6) To permit error modulation rates above the interferring amplitude scintillation rates of 50 cps, it is desirable to be able to complete one complete azimuth and elevation error sampling in 1 ms or less. This rate of sampling requires a switching time of 23 microseconds or less. It should be noted that error sampling rates of 100 cps or

greater are more than adequate for use by the mechanical servo mechanisms commonly utilized for antenna positioning. The higher sampling rates are thus valuable for error coding purposes only.

7) The final requirement is that the converter be suitable for antenna feed mounting and thus as compact and lightweight as possible.

CONVERTER EXPERIMENTAL RESULTS

Single channel converters have been fabricated and evaluated by Scientific-Atlanta for three different frequency bands. Photographs and measured characteristics of these units are given in Figures 5, 6, 7, 8, and 9.

To meet the design requirements for proper converter operation, it was necessary to develop solid-state switches, isolators, and phase shifters specifically for this application. To this date, four different converter units have been constructed and evaluated.

The first unit constructed operated from 1435 - 1540 MHz (L-band) and is shown in Figure 6. This unit was successfully utilized in a high performance missile tracking system. The requirement for lighter-weight, broadband operation, and higher efficiency led to the development of a unit covering the complete upper UHF telemetry band of 1435 - 2300 MHz. A dual-channel UHF unit for a polarization diversity system is shown in Figure 7. A 215 - 265 MHz unit, designed to operate with a phase monopulse antenna system is shown in Figure 8.

A low loss, high reliability waveguide unit utilizing ferrite latching phase shifters for signal processing is shown in Figure 9. This unit is being used in the U. S. Army Satellite Communications Agency's transportable ground terminal produced by Radiation, Inc.

	L-Band*	Upper UHF	P-Band	X-Band
Frequency	1435 - 1540	1400 - 2300	215 - 260	7.25 - 7.75
Construction	Coax	Coax	Coax	Waveguide
Sum Channel Insertion Loss	*	1.5 db	1.0 db	0.5 db
Phase Tracking Over Band and Temperature	±20°	±20°	±15°	±20°
Error Channel Insertion Loss (less directional coupler)	*	3.0 db	3.0 db	0.5 db
Isolation Between $\Delta\phi$ and $\Delta\theta$ signals	15 db	26 db	45 db	20 db
VSWR Sum Channel	1.3:1	1.2:1	1.1:1	1.35:1
Switching Time	10 μsec	10 μsec	10 μsec	10 μsec
Operating Temperature	-35°C to +60°C	-35°C to +60°C	-35°C to +60°C	-35°C to +60°C

*Design replaced by upper UHF unit. Requires 2 preamplifiers ahead of converter. Insertion loss in both channels is 3 db.

Figure 5

Characteristics, Single Channel Monopulse Converters

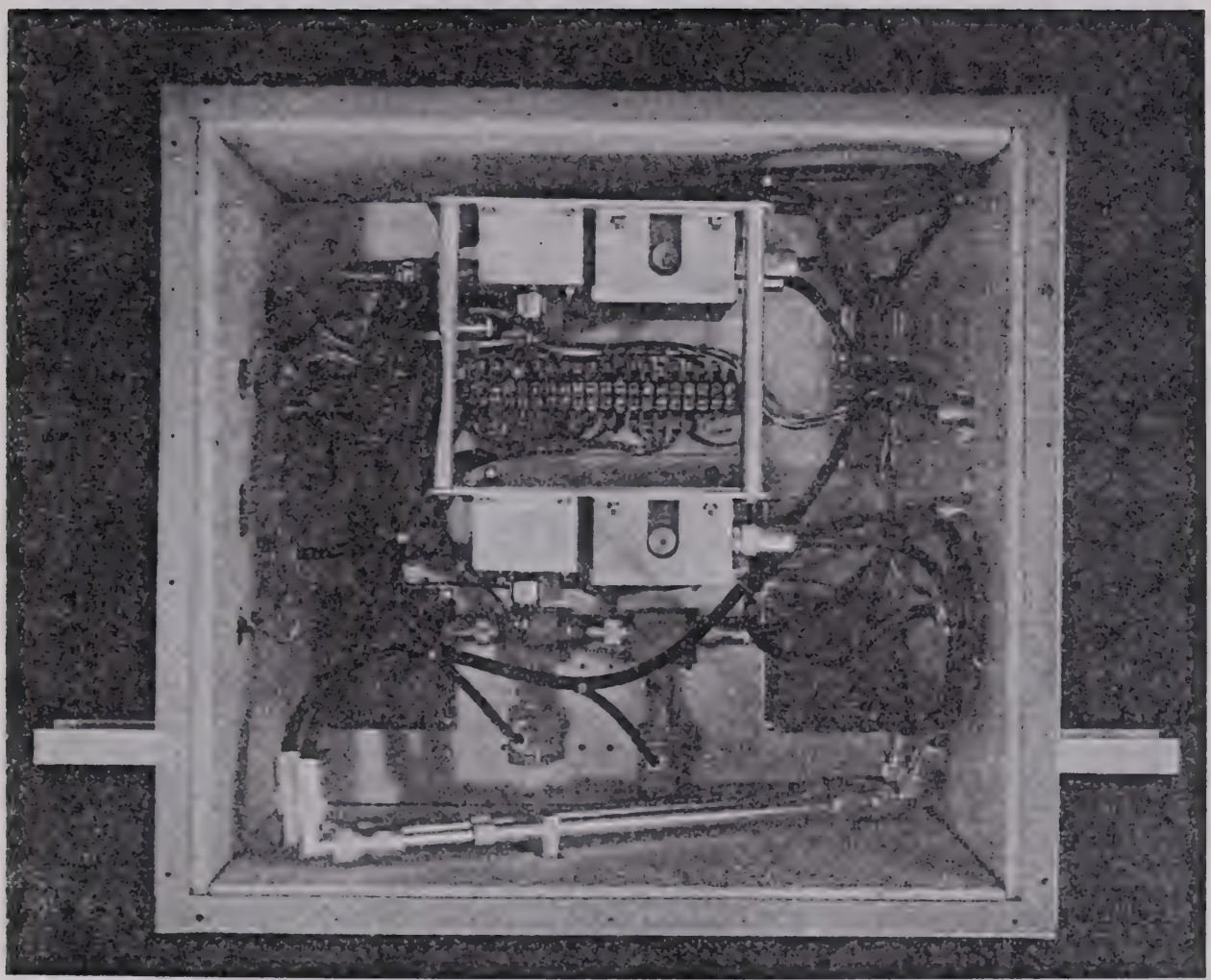

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Figure 6

Single Channel Mono-Scan
Converter, L-Band

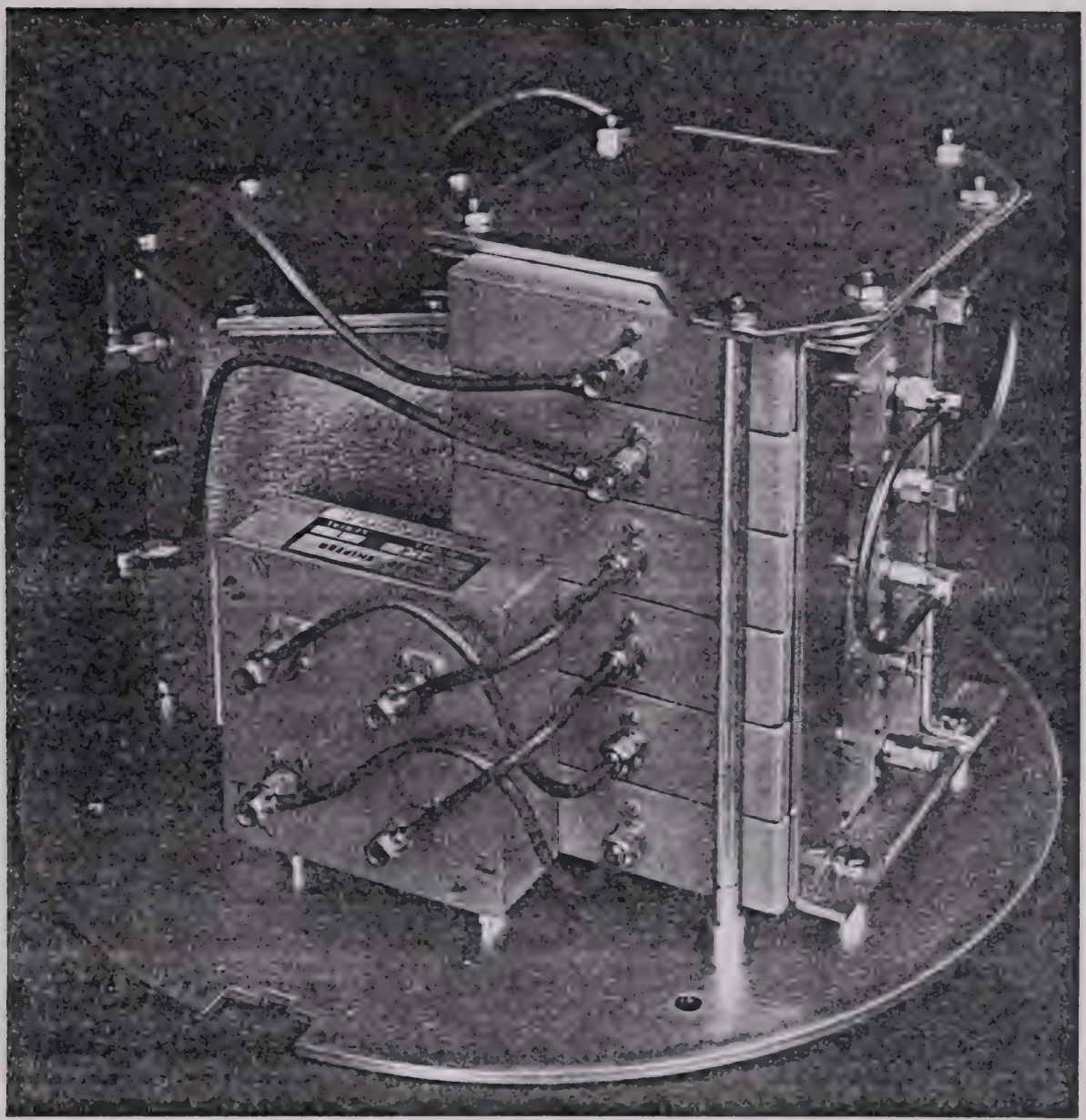

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Figure 7

Single Channel Mono-Scan
Converter, UHF

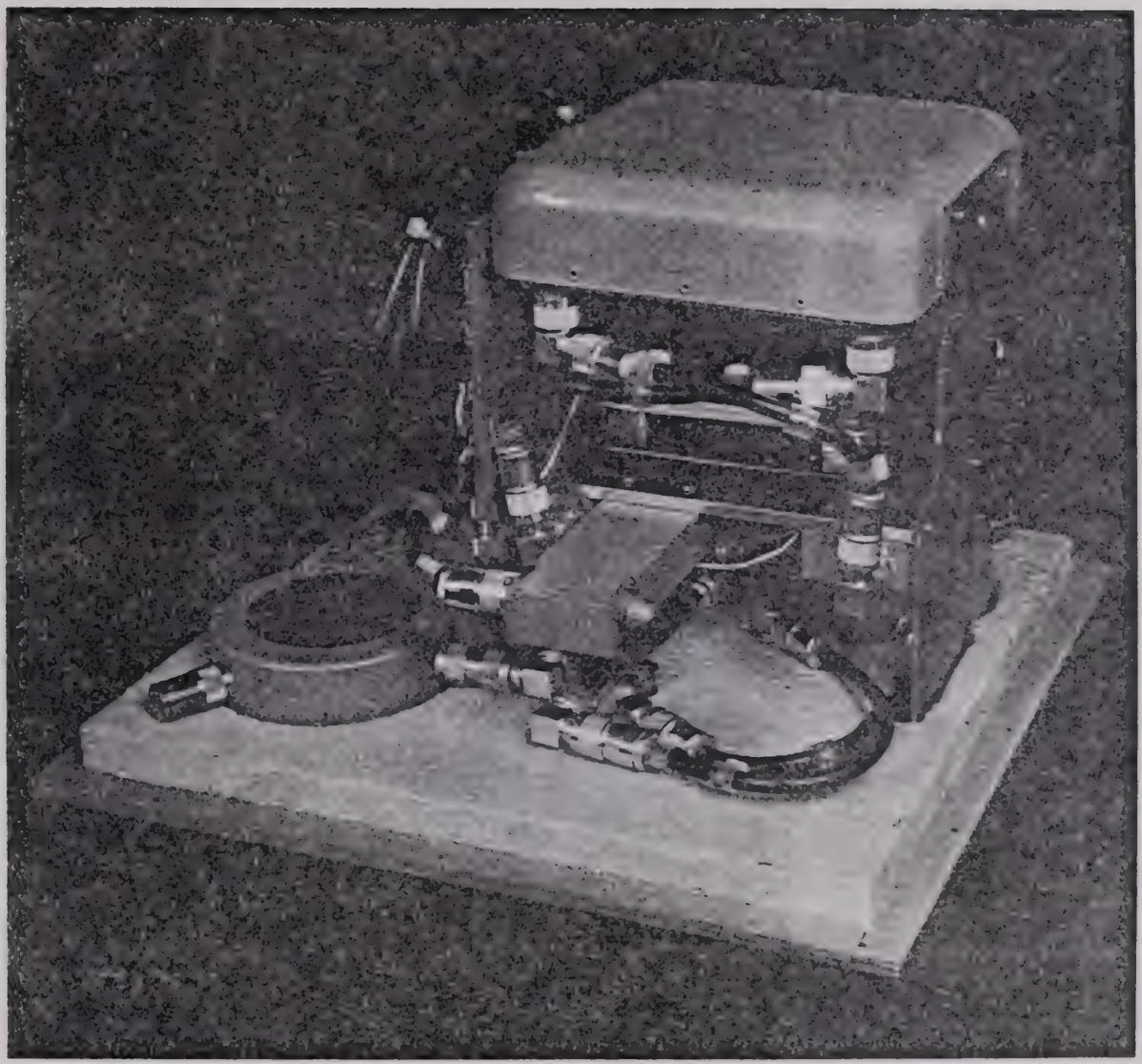

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Figure 8

Single Channel Mono-Scan
Converter, VHF

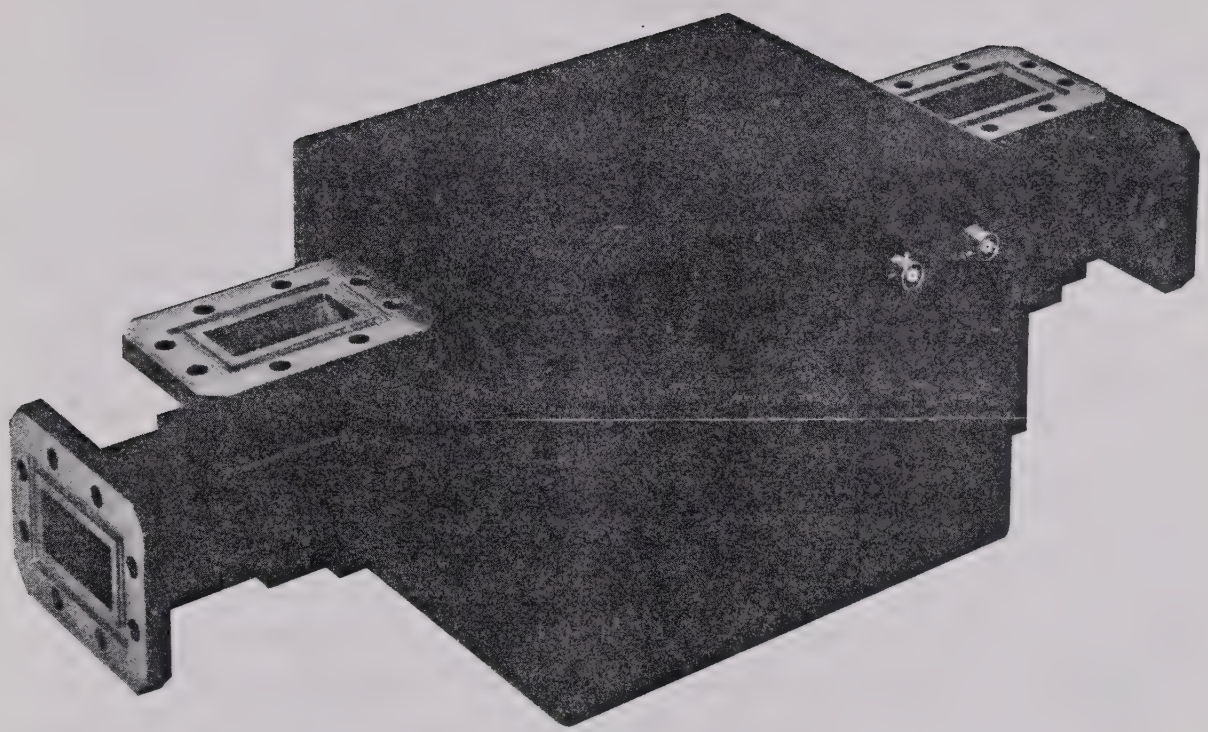

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Figure 9

Single Channel Mono-Scan
Converter, X-Band

RF SUBSYSTEM DESIGN

In the single channel monopulse systems of the type described, the S/N ratio is directly reduced by the amount of attenuation introduced by the coupler in the sum channel. Attenuation in the difference channel serves to reduce the percent modulation for a given angle off-boresight. To maintain a constant servo loop gain, the gain of the servo system after the receiver must be increased to compensate for the "loss" in servo gain in the RF portion of the system. The noise introduced at low S/N ratios is amplified such that the effect of attenuation in the RF difference channels becomes that of increasing angular jitter at low S/N ratios. It can be shown that for low signal to noise ratios incoherently derived receiver AGC voltage causes major changes in servo loop gain. This applies to any tracking system configuration where envelope detection is used. For telemetry tracking, AGC effect dominates the noise jitter effect in determining tracking performance at low S/N ratios.

Three possible configurations of the RF subsystems are shown in Figure 10. The first provides signal modulation before amplification, thus requires only one preamplifier and receiver. The coupling coefficients normally are chosen for minimum attenuation in the sum channel. The value of the angular tracking jitter is a function of the S/N ratio, the antenna design, the total attenuation in the difference channel before preamplification, and the IF and servo bandwidths. The values of angular jitter at low S/N ratio are small when compared to the antenna beamwidth if the coupling coefficient in the difference channel is 10 db or less.

If the need for ultra precision tracking at low signal noise ratios exists, the configuration of Figures 10B and 10C may be used. The preamplifiers used must maintain phase and amplitude stability over the frequency and temperature ranges of operation.

Data outputs completely free of converter introduced amplitude modulation may be taken with either configuration 10B or 10C, if such a need exists.

REFERENCE

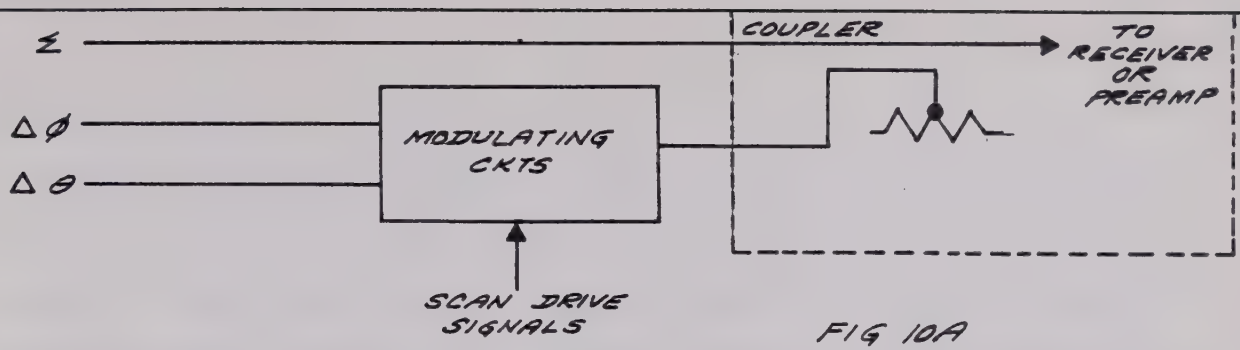

FIG 10A

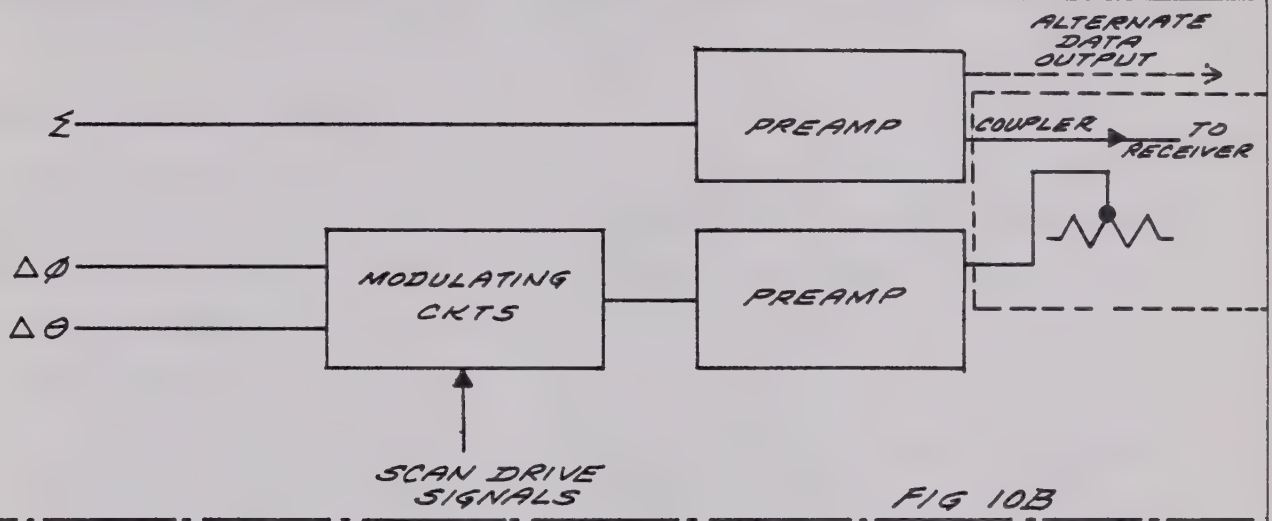

FIG 10B

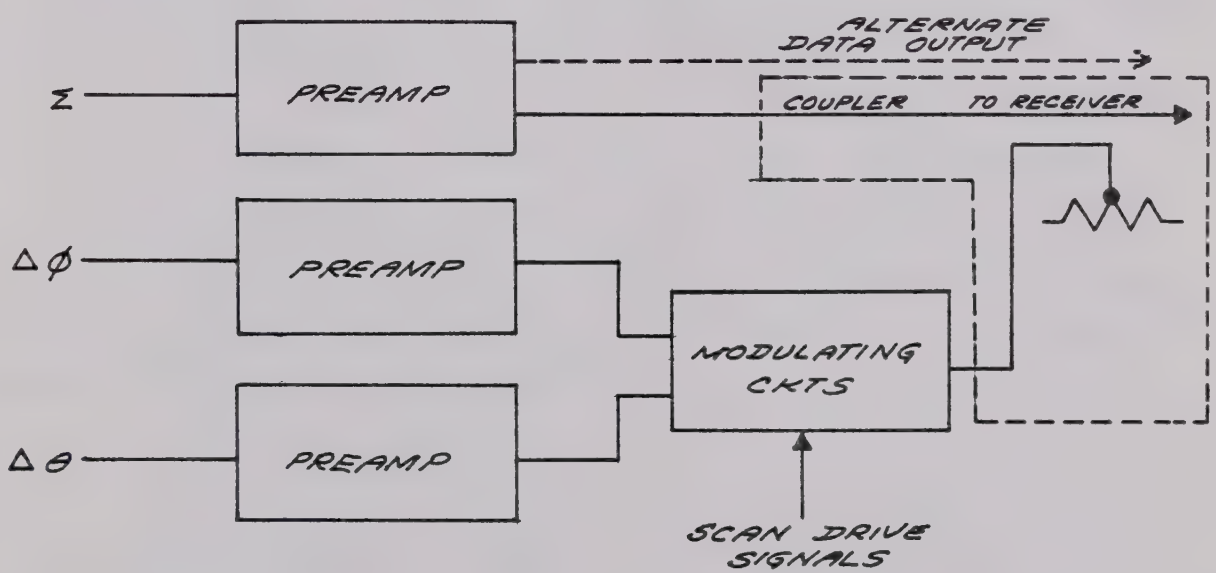

FIG 10C

FIGURE NO. 10

TITLE

RF DESIGN CONFIGURATIONS

RECEIVER DESIGN

Any single channel superhetrodyne telemetry receiver is suitable as the tracking receiver. The use of high frequency error sampling permits the use of relatively wide bandwidth AGC loops, a desirable feature in automatic tracking systems. As with other tracking systems, phase lock loops can be utilized to yield large improvements in tracking sensitivities, provided that sufficient narrow-band carrier is available for this use.

EXPERIMENTAL RESULTS

L-band and P-band automatic tracking systems utilizing single channel monopulse are shown in Figures 11 and 12. A transportable 18-foot diameter upper UHF system featuring frequency and polarization diversity is presently under construction at Scientific-Atlanta. Characteristics of these systems are shown in Figure 13.

Measured values of noise jitter for the P-band system (25-degree beamwidth) along with projected values of noise jitter for the 18-foot diameter system operating at 1700 MHz (2.5 degrees beamwidth) are plotted in Figure 14. Both systems use one preamplifier after modulation (Figure 10A).

The effect of AGC noise error on servo open loop gain is plotted in Figure 15. In all systems a 20 cps AGC bandwidth was obtained. Tests were run on the P-band antenna system to demonstrate the effectiveness of the coded scan techniques. Figure 15 shows a plot of the measured antenna motion introduced by a cyclic modulated transmitting signal for a constant frequency scanning mode and for a simple coded scan mode.

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Figure 11

Single Channel Monopulse
Auto-Tracking System,
L-Band

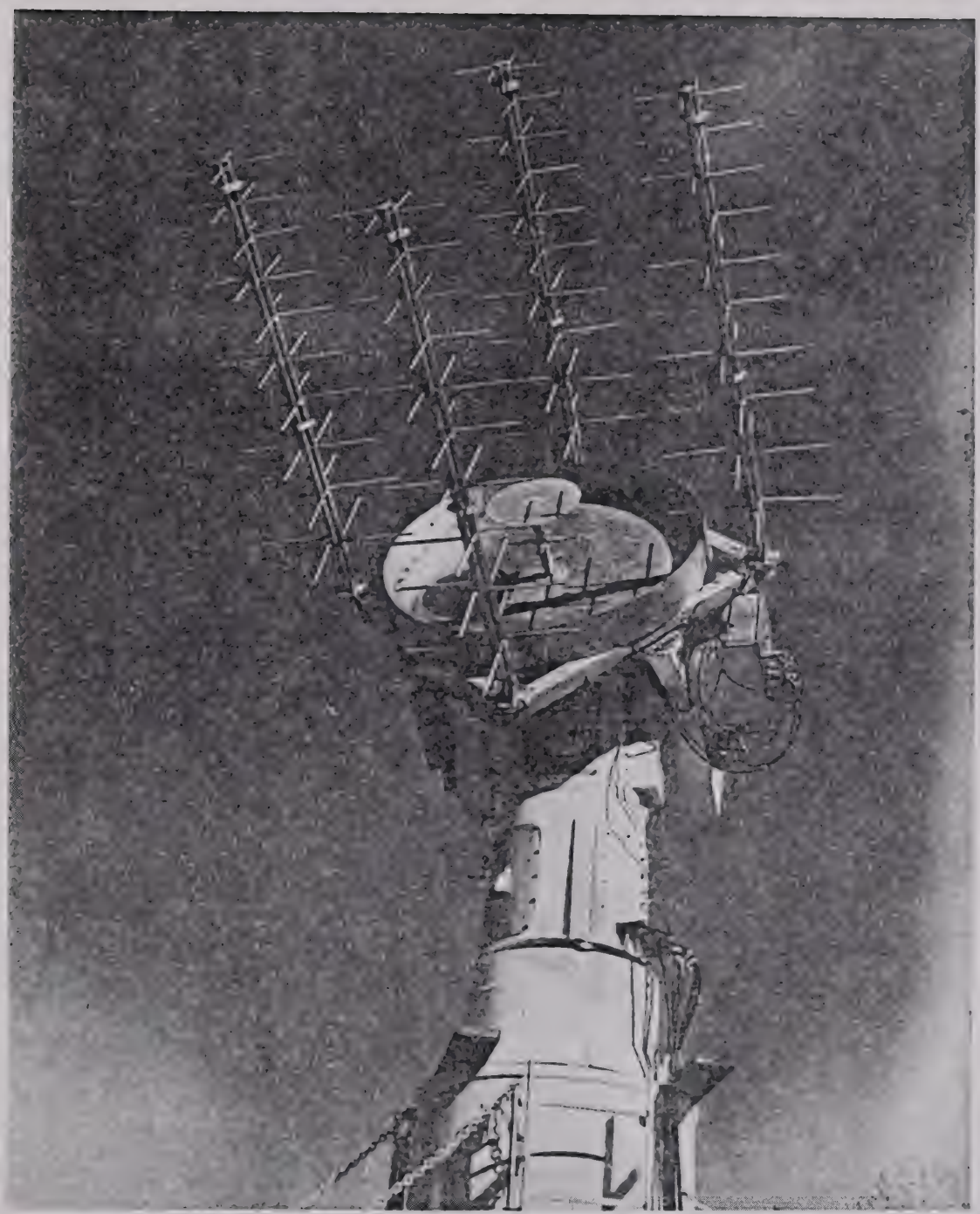

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Figure 12

Single Channel Monopulse Auto-Tracking System, VHF

	P-BAND	L-BAND	L- & S-BAND
Frequency (MHz)	215-265	1435-1535 Track and Receive 4900-5400 Receive 9800-10,000 Receive	1700-1800 Track and Receive 2200-2300 Track and Receive
Antenna Type	4-Element Phase Monopulse, Dual Polarized Log Periodic	8-Foot Reflector, Amplitude Monopulse, Dual Polarized	18-Foot Reflector, Amplitude Monopulse, Dual Polarized
Antenna Gain, Above Isotropic	17 db	27 db (1435-1535 MHz) 37 db (4900-5400 MHz) 44 db (9800-10,000 MHz)	36 db (1700-1800 MHz) 38 db (2200-2300 MHz)
Servo Bandwidth	0.75 cps	1.5 cps	1 cps
Acceleration, Each Axis	$15°/sec^2$	$15°/sec^2$	$15°/sec^2$
Velocity Constant	100	200	400
Tracking Angles	±360° Azimuth -5° to +85° Elevation	±360° Azimuth -5° to +85° Elevation	Continuous Azimuth -5° to +85° Elevation
Wind, Operating	60 mi/h, maximum	60 mi/h, maximum	60 mi/h, maximum
Survival Wind	120 mi/h	120 mi/h	120 mi/h
Temperature, Operating	-35°C to +60°C	-35°C to +60°C	-35°C to +60°C

Figure 13

Essential Characteristics,
Scan Coded Single Channel
Monopulse Systems

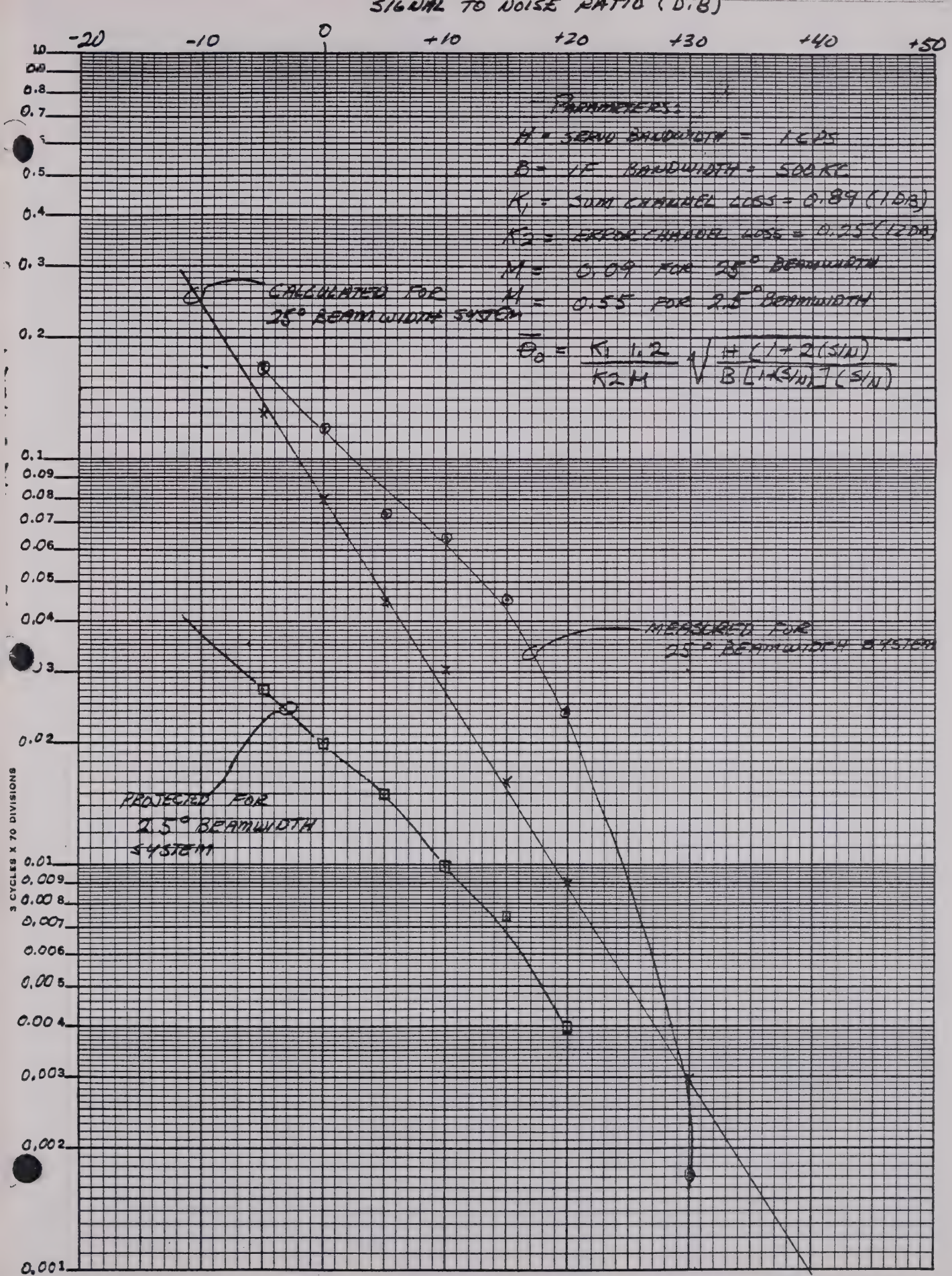

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FIG. 14 - RMS ANGULAR NOISE JITTER V.S. SIGNAL TO NOISE RATIO

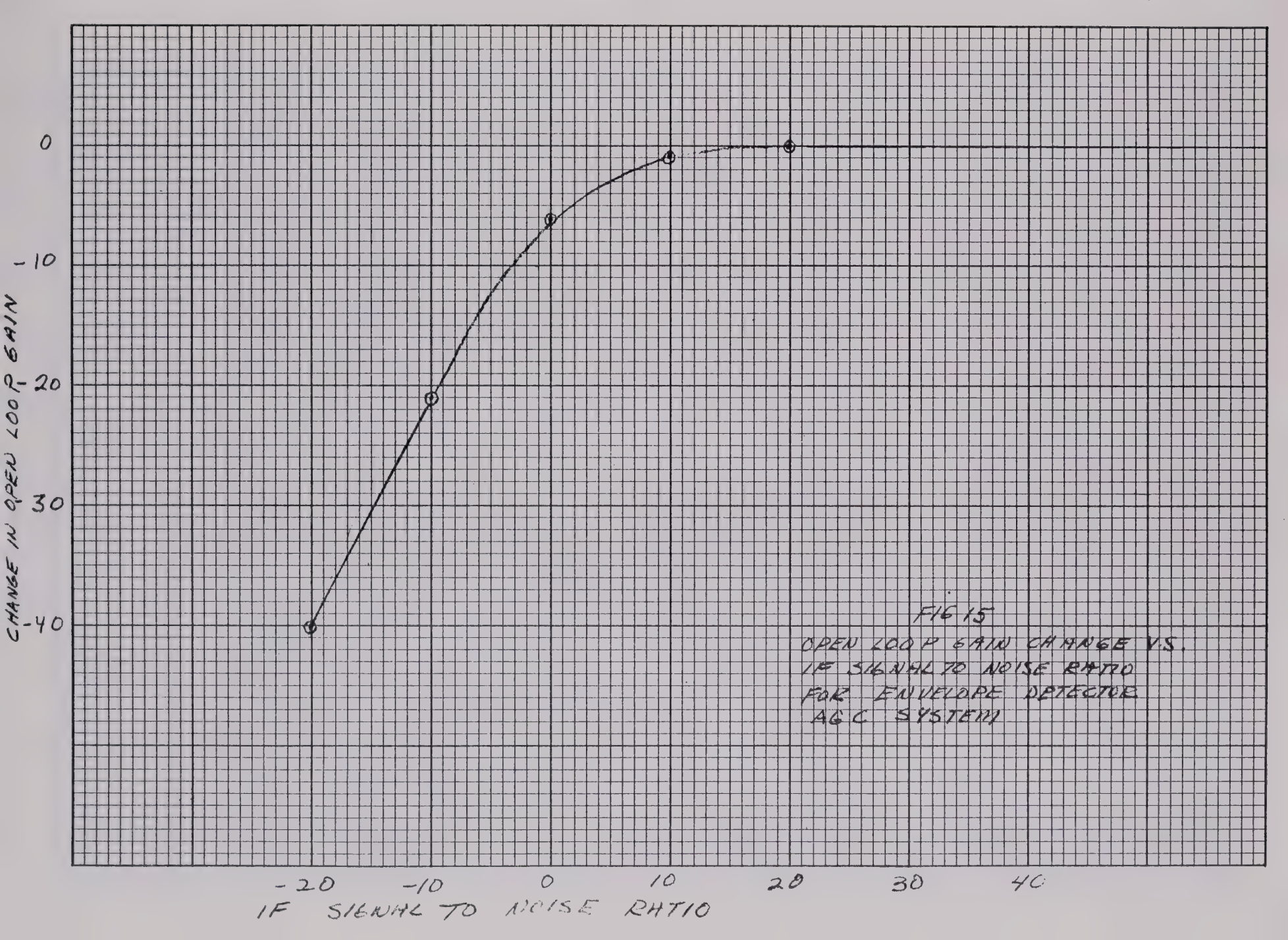

FIG 15
OPEN LOOP GAIN CHANGE VS.
IF SIGNAL TO NOISE RATIO
FOR ENVELOPE DETECTOR
AGC SYSTEM

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3 CYCLES X 140 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

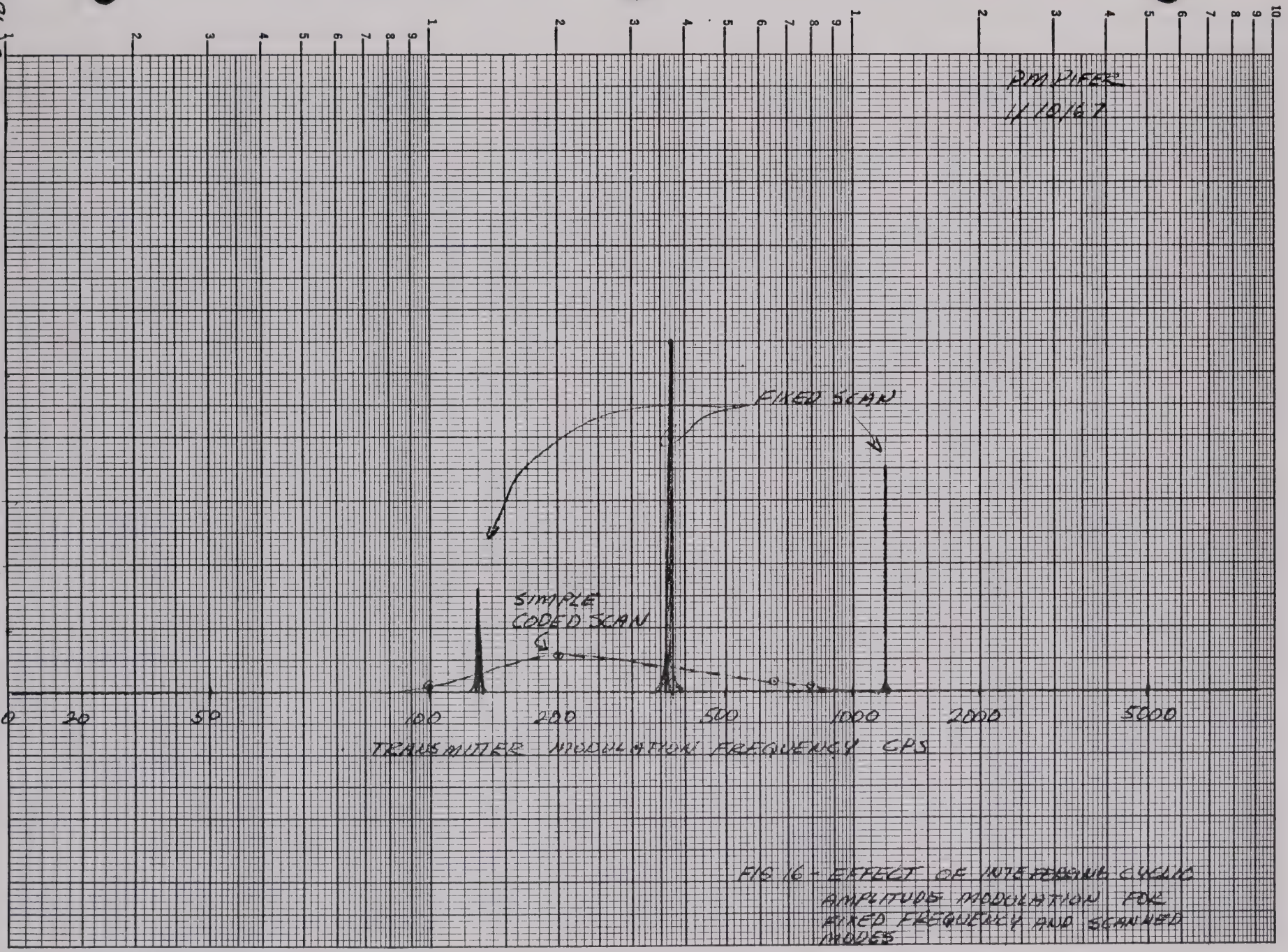

FIG 16 - EFFECT OF INTERFERING CYCLIC AMPLITUDE MODULATION FOR FIXED FREQUENCY AND SCANNED MODES

APPENDIX I

EFFECT OF PHASE MISALIGNMENT BETWEEN SUM AND DIFFERENCE SIGNALS, SINGLE CHANNEL MONOPULSE CONVERTER

It is of interest to examine the effects of phase tracking errors which may be introduced by the converter. Figure 17A shows the sum channel and difference (error) vectors, with a RF phase angle error β between the two.

The RF voltage magnitudes during the two states of sampling are:

$$V_1 = \sqrt{(\Sigma + \Delta\phi \cos\beta)^2 + (\Delta\phi \sin\beta)^2} \qquad (1)$$

$$V_2 = \sqrt{(\Sigma - \Delta\phi \cos\beta)^2 + (\Delta\phi \sin\beta)^2} \qquad (2)$$

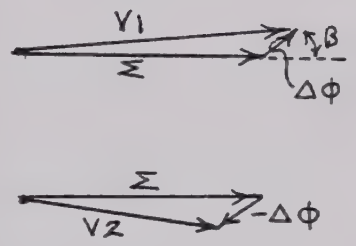

FIG. 17A

As the tracking error is reduced to zero, or if β is small.

$$\Sigma >> \Delta\phi \sin\beta \qquad (3)$$

$$V_1 \tilde{=} \Sigma + \Delta\phi \cos\beta \qquad (4)$$

$$V_2 \tilde{=} \Sigma - \Delta\phi \cos\beta \qquad (5)$$

The peak to peak variation is

$$V_1 - V_2 = 2 \phi \cos\beta \qquad (6)$$

The prime effect of RF phase shift is to vary the error modulation and thus the servo loop gain.

Maintaining phase tracking accuracy to ±20 degrees over the frequency and temperature range of operation will introduce a servo loop gain change of only 6%.

Another interesting and valuable feature of the modulation process is that quadrature voltages do not introduce amplitude modulation. Thus, variations in antenna difference nulls due to quadrature components will not cause boresight shifts.

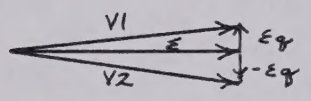

FIG 17B

MP MASTER
MA29847